ESTIMATION OF AGE AND GROWTH OF THE INDIAN OIL-SARDINE, *SARDINELLA LONGICEPS* VAL.

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Abstract

Estimates of age and rate of growth of the Indian oil-sardine, *Sardinella longiceps* Valenciennes, have been made through a study of length frequency distributions obtained during the seasons from 1961-62 to 1965-66 at Calicut. With the availability of very small juveniles, a lifetime growth curve of the fish has been constructed and evidences advanced to prove that the commercial fishery of juveniles belong to O-year class. It is estimated that a growth of about 60-65 mm is attained in one month and about 95-110, 110-125, 125-140, 150-160 and 170-180 mm in 2, 3, 6, 12 and 24 months respectively. Although in rare instances the fish may live up to 3 years, the normal life span is found to be about 2½ years.

An overall picture of the entry of different juvenile broods indicates that those born during June to August manifest themselves strongly in the fishery while those that result from September or October spawning fail to establish themselves due to their weaker numbers. The earlier broods have the fastest rate of growth as compared to the later recruits. However, the differences in the growth appear to be compensated when the fish pass through the spawning season at the end of first year when a spurt of growth activity is witnessed.

The fastest rate of growth has been observed when the fishery proved a failure as in 1963-64 season and very slow growth when the fishery was exceptionally good as in 1961-62 and 1964-65 seasons. It is shown that the success of any season's fishery is largely dependent on the successful spawning and the survival rate in that year. The possible influence of the amount of rainfall during the spawning fortnights on the spawning potentialities of the fish is indicated.

Introduction

From the widely fluctuating nature of the oil-sardine fishery, it has become clear that the fishery depends on only a few age groups, the fluctuations depending upon the strength of the incoming broods every year. After the first report on the age and growth of the oil-sardine by Hornell and Nayudu (1924), this aspect has received considerable attention from the subsequent workers. Hornell and Nayudu (1924) found a very rapid rate of growth in the early stages resulting in a length of about 15 to 17 cm at the end of first year, 19 cm at the end of second year and about

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19.5 cm at the end of 2½ years which they considered as the normal life span of the fish. Chidambaram (1950), on the other hand, estimated an average length of 10.0, 14.5, 18.3 and 20.5 cm at the end of the first to fourth year respectively, which found agreement in general with Nair (1953) and most of the subsequent investigators. It is clear from the past studies that there are two important views, that of the pioneer workers considering fish of 10 cm length as O-year class and that of the majority of later workers who consider that it is I-year old. The disagreement is around the estimation of the growth of fish during the first year. With the object of estimating the age of the fish when first recruited to the fishery the following study was carried out with material obtained from July 1961 to March 1966 at Calicut.

METHOD

Random samples each consisting of at least 25 fish were drawn normally twice a week from the fish landing place at Calicut. The length frequency method is followed in this study. Whenever there were any departures from the normal size groups, more samples were taken than the routine. Since the controversy is on the age at first recruitment, more samples were taken during the first 3 or 4 months from the first appearance of the juveniles than in the succeeding months to obtain a reliable estimate of the rate of growth.

The size groups are referred to as 100, 105 mm etc., for the fish ranging from 100 to 104, 105 to 109 mm respectively. As the number of fish measured each month was not constant, the length distributions were made comparable by converting the frequencies into percentages of the total for the month. The year reckoned is from July to next June.

LENGTH FREQUENCY DISTRIBUTION AND PROGRESSION OF MODAL GROUPS.

The length frequency distributions for the seasons 1961-62 through 1965-66 are shown in Figs. 1 to 3 and the modal progression of the different groups (A to G) is shown in Figs. 4 and 5.

The mode G represented the recovering spawners and F, the virgin spawners in the 1961-62 season (Figs. 1, 4). While G at 185 mm was not of any significance after August, F progressed from 155 mm in July to 170 mm by next October. Two spurts of growth activity could be seen for this group, once during July-September 1961 and again during May-July 1962, both interestingly coinciding with the spawning season, the growth otherwise being static during the intervening period between September 1961 and May 1962. Group A, representing the new broods encountered for the first time in the fishery, started at 115 and 110 mm in October and November respectively and progressed to 150 mm by July 1962, 175 mm by July 1963 and ended up at 185 mm by March 1964. Of the two sub-groups recruited in 1962, B_1 representing the larger specimens, appeared with a modal size of 140 mm in October 1962 whereas B_2 starting at 65 mm in early September and registering a very rapid rate of growth caught up with B_1 by July 1963 when the group showed a modal size of 150 mm. By June 1964 the group shifted to 170 mm and disappeared after October 1964 adding 10 mm more. Group C of 1963 was represented by 3 sub-groups which through very rapid growth attained a length of 170 mm by June 1964, reached 185 mm by July 1965 and disappeared after October 1965. Group D of 1964 started with two sub-groups at 80 and 115 mm in August and progressed through a rather slower growth to 145 mm by July 1965 and 155 mm by March 1966. Group E of 1965, represented by two broods, showed the most rapid rate of growth during the early stages. E_1 grew from 105 mm in late August to 145 mm in December whereas E_2, starting at 35 mm in early August, went up to 140 mm by March 1966.

One of the major features that emerges from the above account is that in all the seasons at least two sub-groups representing two broods were seen recruited into

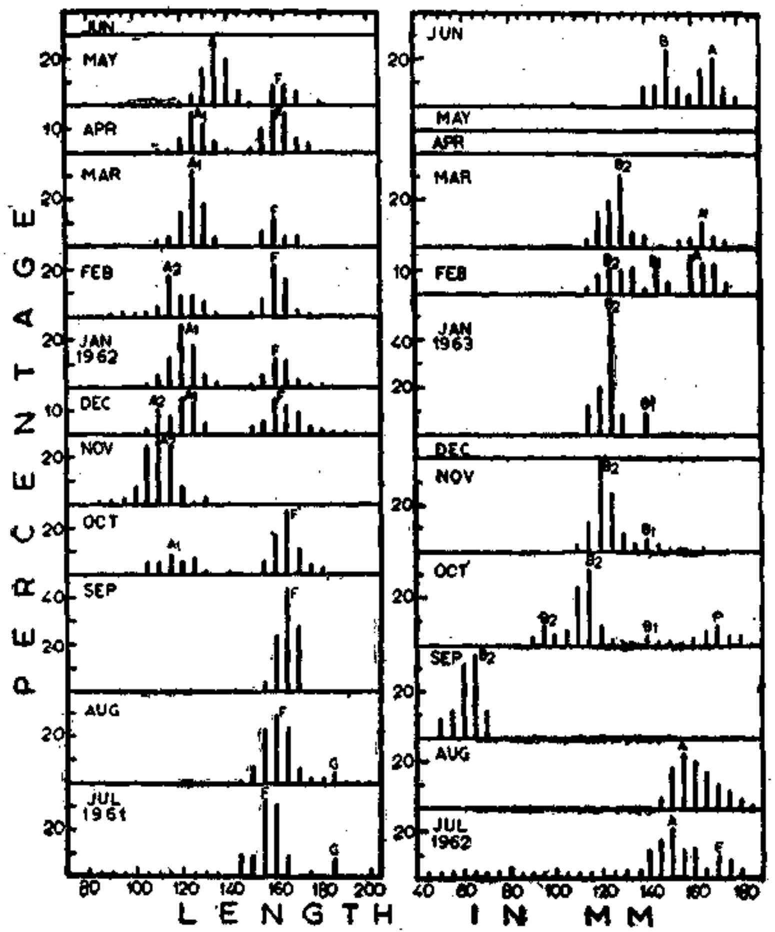

FIG. 1. Length frequency distribution of the oil-sardine for the seasons 1961-62 and 1962-63.

the fishery in the juvenile stage, the sizes at and the months of incidence differing during the different years. Of these two sub-groups, the earlier recruits, namely, those with the mode at a larger size showed lesser growth increments after October as compared to the later recruits, which by virtue of increased rate of growth, appeared to bridge the difference in sizes progressively and to catch up with the former after an interval of about 10 months, to such degree that their modal sizes merged into a single one, which formed the size at first maturity. Roughly a length of 150 mm was thus attained at this stage for groups A and B of 1961 and 1962 respectively, 170 mm for group C of 1963 and 140 mm for group D of 1964. This differential rate of growth of the various groups for the same interval of time is to be studied in relation to their abundance. From the account of Prabhu (1967), it is seen that while the seasons

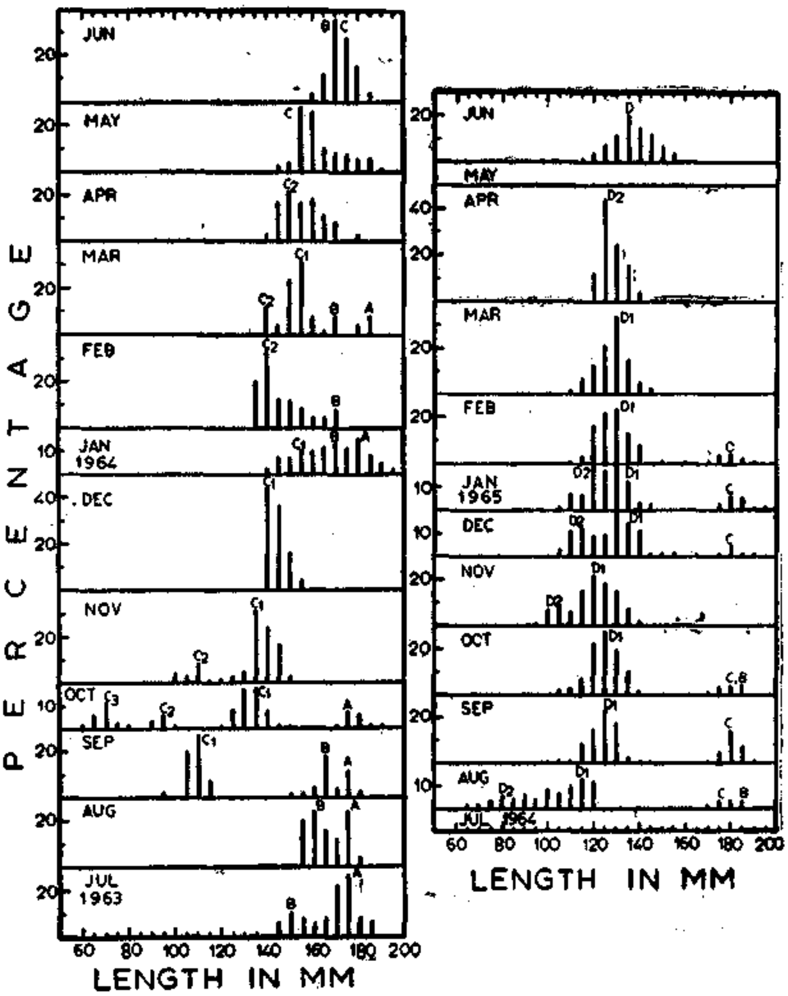

FIG. 2. Length frequency distribution of the oil-sardine for the seasons 1963-64 and 1964-65.

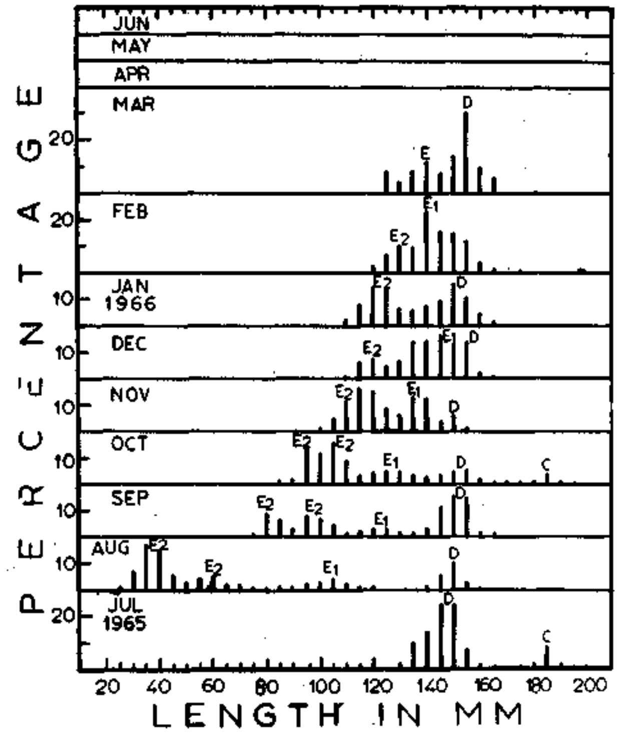

FIG. 3. Length frequency distribution of the oil-sardine for the season 1965-66.

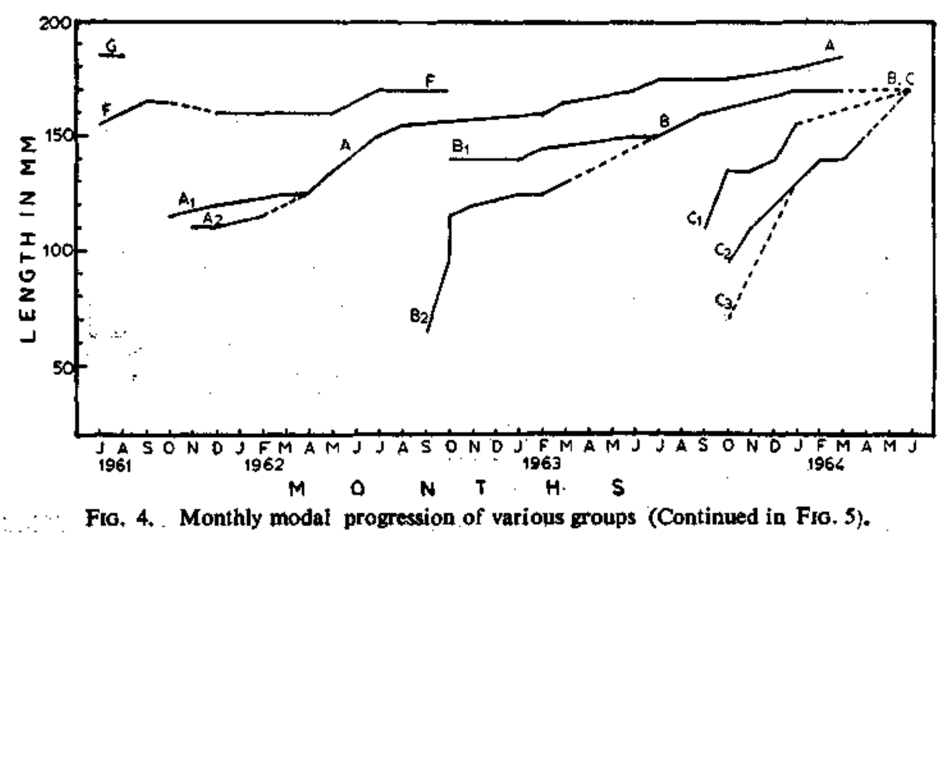

FIG. 4. Monthly modal progression of various groups (Continued in FIG. 5).

of 1961 and 1962 were good, that of 1963 was lean, only to revive with a bumper crop in 1964. Thus, with relatively lesser competition and availability of more food, the recruits of 1963 enjoyed a very rapid rate of growth, whereas, with overcrowding and more severe competition for food in 1964, the recruits had to go through a slower session of growth.

During the succeeding year, A adds 25 mm, B 20 mm, C 10 mm and D 20 mm. After this, the growth increment is limited to about 10-15 mm only depending on how long the group managed to remain distinctly during the third year after its first entry

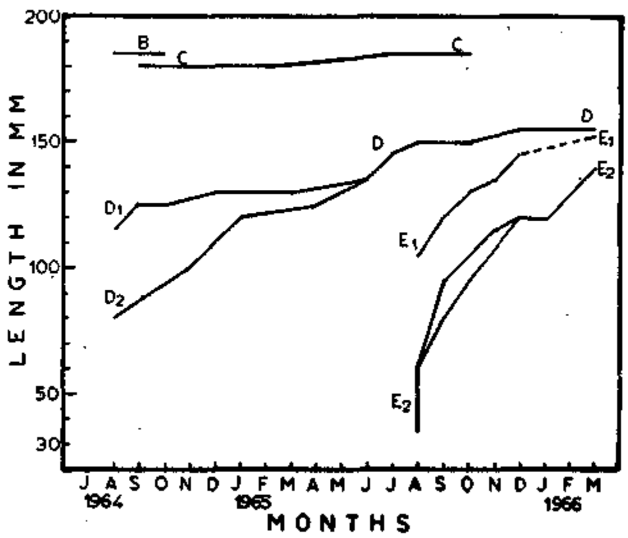

FIG. 5. Monthly moda lprogression of various groups.

into the fishery. This period of continued presence was at a maximum of 8 months during the third year for group A. For groups B, C and F, it was only 3 months and for group G, only 2 months.

Unlike many other fishes, the oil-sardine registers an acceleration of growth along with the ripening of the sexual products just prior to and during the spawning season (Antony Raja, 1967; Bensam, 1968).

AGE AND GROWTH

Growth during the first year

From the foregoing account it is seen that if the fish reaching a length of 150 mm is considered as at age n year, then it follows that at $n+1$ year a length of about 170-180 mm is recorded and during $n+2$ years a length of 185 mm or more is attained when the fish normally disappear from the catches. The problem now is to determine n so that the growth picture will be complete. In other words, the question is, at the time of recruitment in juvenile stage during August-October period, what is their age? Since the age of the juveniles obtained during this period forms the topic of controversy (Prabhu and Dhulkhed, 1967), the details of samples examined during August-October period of 1965 are presented in Table 1 as this season offers the best

TABLE 1. *The details of samples of juveniles examined on different dates from August to October 1965*

Date	No. of samples	No. of fish	Size range (mm)	Modal sizes (mm)	Dominant modes for the period (mm)
2—8—65	2	100	33—58	40	35
3—8—65	1	50	29—47	35	
4—8—65	3	150	29—62	30,35,40	
5—8—65	2	100	32—60	35	
6—8—65	1	50	33—50	35,40	
20—8—65	1	50	46—70	55	60,105
21—8—65	1	50	49—101	60	
23—8—65	2	100	51—122	60,70,105	
24—8—65	1	50	91—118	95,105	
30—8—65	1	50	83—119	85,105	
22—9—65	1	50	78—99	80,95	80,95,120
25—9—65	1	50	88—136	100,120	
7—10—65	3	150	89—126	95,100,105	95,105,130
15—10—65	1	21	110—136	130	
22—10—65	1	25	121—140	130	
25—10—65	1	50	105—129	105	

evidence for the entire study period. The age of 35 mm group of early August and 60 mm of late August cannot be in doubt for it is quite certain that they were the products of the current spawning season, commencing in June. An addition of 25 mm was thus noticed for this group during the 2-3 week interval. In the last week of September the modes at 80 and 95 mm could be traced to represent the growth of juveniles seen at the end of August, namely the 60 mm modal group. These two modal groups separated by 15 mm were treated as to constitute one major group exhibiting a small differential growth rate because during the first week of August, the daily modal sizes were found to fluctuate between 30 and 40 mm and during the last week between 55 and 70 mm. It should, then naturally follow that 95 and 105 mm groups obtained for October represented further growth of the same group(s). Thus, it is possible to trace beyond any doubt a modal group of about 100 mm obtained in

September-October to represent the offspring of the current year's spawning. This group which is designated as E_2 progressed from 35 mm in early August to about 100 mm in early October, covering a period of 2 months during which a growth of about 65 mm was registered. These fish can be safely surmised as to have come from a spawning that was very recent, not more than a week or two prior to their first appearance. Thus, this group that had a modal size of 95-105 mm in early October cannot be older than about 10 weeks. The same criterion can now be applied to the group E_1 which appeared at 105 mm in late August. This group, being the earlier recruits facing lesser competition for food and space, naturally can be expected to register a faster rate of growth than E_2, in which case, it should have come from a spawning that was about 2 months earlier, namely, late June. Thus, it appears that there might have been two major spawnings, one in late June-early July and the other in late July-early August periods which contributed to the two sub-groups, E_1 and E_2. The differential growth rate and the consequential differences in the modal groups are inevitable when the spawning is likely to be spread over a few days in a month.

In like manner, the other groups of earlier years can be treated and traced to the probable period of their birth. In Table 2 are shown the modal sizes of the juveniles when they first appeared in the fishery and their probable time of birth during the respective spawning seasons. The latter is chiefly presumptive based on the existing

TABLE 2. *The modal size of juveniles on their first appearance in the fishery during 1961-1965 shown as recruits from the respective spawning periods*

Year	and Month	Modal size (mm)	Recruited from the spawning of	New Moon Day
1961	October	$A_1=115$	July	12—7—61
	November	$A_2=110$	August	11—8—61
1962	October	$B_1=140$	June-July	1—7—62
	September	$B_2=65$	July-August	31—7—62
1963	September	$C_1=110$	July	20—7—63
	October	$C_2=95$	August	19—8—63
	October	$C_3=70$	September	17—9—63
1964	August	$D_1=115$	June	10—6—64
	August	$D_2=80$	July	9—7—64
1965	August	$E_1=105$	June-July	29—6—65
	August	$E_2=35$	July-August	28—7—65

indirect evidences. Devanesan (1942) collecting oozing specimens and planktonic eggs had remarked about the likelihood of spawing taking place around the new moon day. Since the present author also had recorded oozing specimens and recently spawned individuals around that period (Antony Raja, 1967) it is believed provisionally that the spawning occurs during the darker phases of the moon. In 1961, the two groups, A_1 at 115 mm in October and A_2 at 110 mm in November may be traced to July and August spawnings respectively. In 1962, while B_1 had a modal size of 140 mm which might represent a growth of 4 months from June-July spawning, B_2 was represented by 65 mm in early September which would have resulted from July-August spawning. In 1963, the three sub-groups recognised as C_1, C_2 and C_3 at 110 mm in September, 95 mm and 70 mm in October respectively might have come from July, August and September spawning respectively. In 1964, D_1 at 115 mm and D_2 at 80 mm were seen in August which, probably representing a growth of 2½ and 1½ months respectively, may be the recruits from June and July spawnings. The data appear to indicate that the spawning activity is at its peak during two consecutive months during the period June-August. It is also seen that a length of about 60-65 mm, 95-110 mm and 110-125mm is attained respectively at the end of first, second and third month, indicating a very rapid rate of growth during the early period.

Average record of birth and growth

To get an overall picture for the entire 5-year period, the monthly data on the length frequency distribution for all the years are combined (Fig. 6). In July, there is a bimodal distribution represented by modes A and B at 150 and

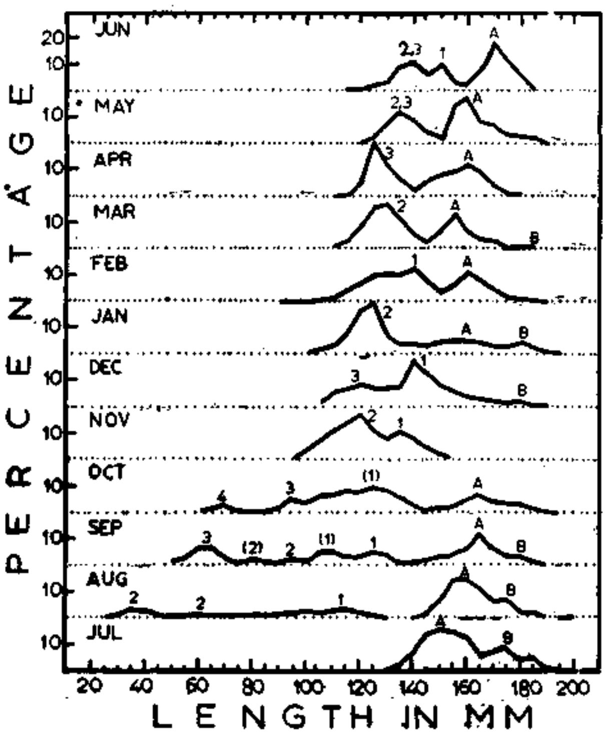

FIG. 6. Monthly length frequency distribution of the oil-sardine for all the years combined. Modes 1, 2, 3 and 4 respectively represent broods from June, July, August and September spawnings.

170 mm respectively constituting the virgin and recovering spawners of 1 and 2 year olds. While the virgin spawners continue appearing through the subsequent months, add about 20 mm more to their length and enter as recovering spawners in succeeding June, B disappears as a modal group by next March, registering during the interval about 10 mm more to their length. Even if they enter the spawning season for the third time, they may only be represented by a negligible percentage and, hence, not prominently seen in the size distribution. Regarding the new incoming broods of juveniles into the commercial fishery, it is seen that a polymodal picture is obtained for the period August to October, whereafter the juveniles are represented by a single or at the most two modes. In August, there are modes at 35, 60 and 115 mm which are largely influenced by the data of 1965. It has been indicated carlier that these 3 modal groups are in real only 2, the 60 mm group representing the growth of 35 mm during the month. Hence the modes are designated as 1 and 2. In September, in addition to these, a third group (mode 3) is seen at 65 mm. In October, a fourth group (mode 4) is noticed at 70 mm. Thereafter how the modes are treated and traced are shown in the figure. Since it is known that the spawning extends from June to October (Antony Raja, 1967), it appeais safe to presume that these 4 recognisable groups represent the offsprings of 4 spawning months during the season. Thus, it is possible to surmise that group 1, born out of June spawning grows to about 150 mm by next June, groups 2, 3 and 4 resulting from July, August and September spawning respectively, reach a length of about 140 mm by next June but might catch up in growth with the earlier recruits during the spawning season when there is a spurt of growth activity. As shown earlier major spawning may be restricted to a period of three months (June to August). The presence of 3 important groups in the overall picture supports this contention. That there is a likelihood of some spawning of much less magnitude in September, is supported by the presence of a fourth group in October. If there should be any spawning of very low intensity still later, in October, as the earlier works indicate (Devanesan, 1942; Nair, 1959; Antony Raja, 1967), the recruits may not contribute so much as to make their presence felt in the fishery as a distinct group. In Table 3 the average modal sizes, at the end of every 3 month period, of the groups that result from the three major spawning months as deduced from Fig. 6 are shown; from this table it is seen that the first born have the fastest rate of growth during the first 3 months, a growth attainable in about 6 months only by the later recruits. Although the late recruits show a slower

TABLE 3. *Average modal length at the end of 3 month periods during the first year for those born in different months*

Birth	Modal length (mm) at the end of 3 months	6 months	9 months	12 months
June	125	140	140	150
July	115	125	135	150
August	110	125	135	160

growth in the beginning, the loss seems to be compensated when they pass through the spawning season in the subsequent year.

Growth variations

The mean lengths obtained during the different months by the various year classes are shown in Fig. 7 with the average length for all the pooled data connected. It is seen that the fastest rate of growth is noticed in 1963 which, as stated earlier, coincided with the failure of the fishery. The slowest growth appears to have taken place in the years 1961 and 1964 when the fishery was exceptionally good. It can also be seen from Fig. 7 that the growth rate during the first 2 months is so rapid that about 70% of growth of the first year and 60% of the life-time growth is achieved then, at which point the inflection in the growth slope takes place. The rate of growth

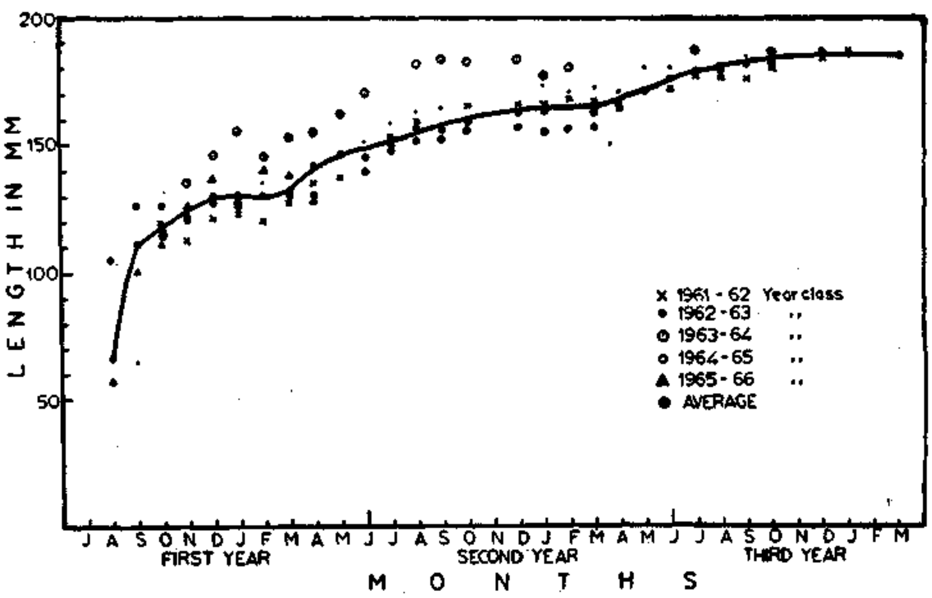

Fig. 7. Growth curve of the oil-sardine. Monthly mean lengths for the different year classes are shown with the overall means for the combined data connected.

declines during the next 3 months, almost comes to a standstill during the subsequent 3 months only to gradually increase later. During the spawning months, growth again shows an upward rise. Further growth follows roughly the same trend as seen during the first year of life, except that the rate is considerably reduced. Broadly speaking, the growth increments are at their peak during June-September period, slacken during October-December, remain level during January-March and begin to rise from April onwards. A similar pattern has also been recorded at Cannanore by Bensam (1968).

Growth parameters

Adopting Walford's (1946) method, the average lengths at monthly intervals were plotted against those of the succeeding month based on the values obtained (*vide* Fig.7). It was noticed that the points up to 3 months appear to fall on a straight line and the others on another, because the growth inflection occurs at the third month. Hence, it was decided to plot the points for lengths relating to a unit time of 3 months, all of which happen to fall on a straight line and well fitted by the least square line Y=29.18+0.8609X(Fig. 8). The l_∞ value of 210 mm obtained

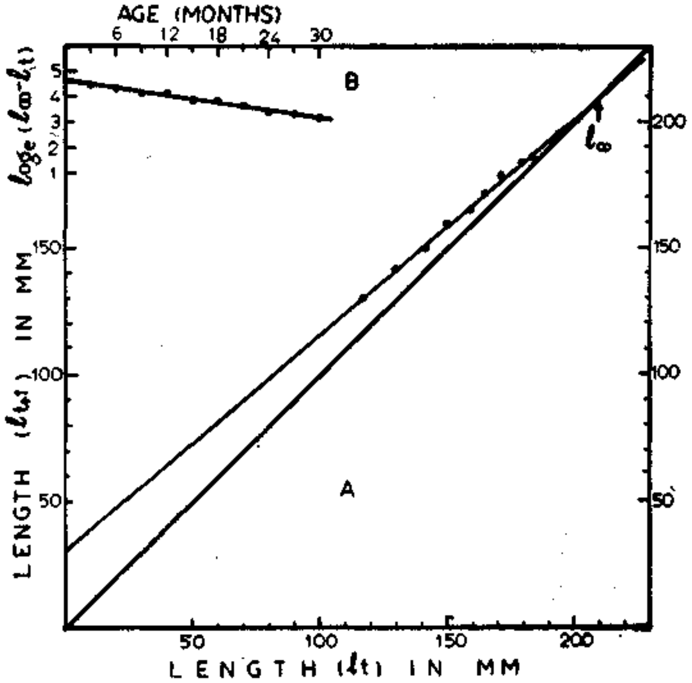

FIG. 8. A. Walford's growth transformation for length of the oil-sardine. B. Loge ($l_\infty - l_t$) plotted against age

is close to the size of the largest fish measured during the investigation, namely, 206 mm. The previous published records also show that instances of fish longer than 210 mm are very rare.

The parameters, l_∞, K and t_0 of the von Bertalanffy growth equation

$$l_t = l_\infty (1 - e^{-K(t - t_0)})$$

where, l_t is the length at age t, l_∞ is the asymptotic length, K is the destruction coefficient and t_0 is the apparent age at length zero, were calculated and the values obtained were l_∞=209.8 mm, K=0.05 and t_0=13.42.

Growth pattern on the west coast

The modal sizes obtained in different months during 1963-66 at various places from Karwar in the north to Cochin in the south are plotted in Fig. 9 with the modal

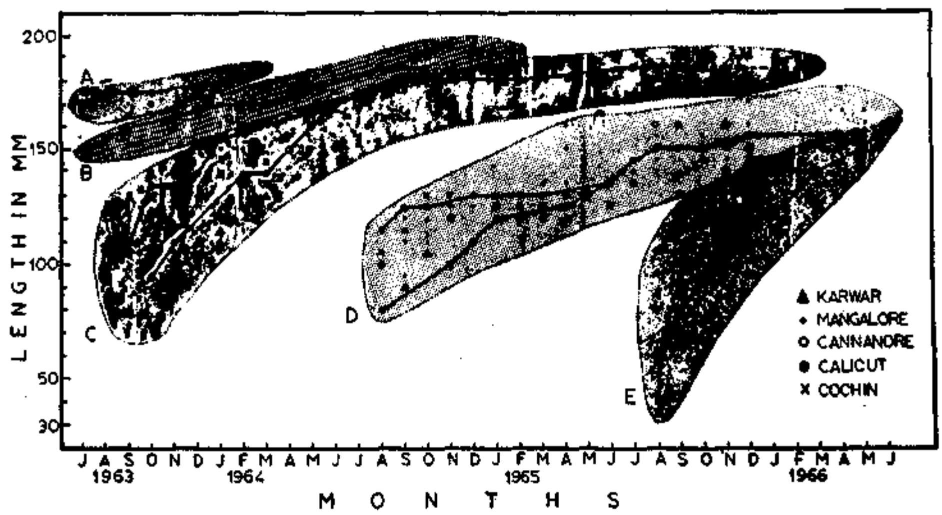

FIG. 9. Monthly modal sizes of oil-sardine at different places along the west coast of India during 1963-1966 seasons showing the growth profiles of different year-classes.

progression at Calicut superimposed. The data relating to the other areas are taken from the quarterly and annual reports of the Director, Central Marine Fisheries Research Institute. The modal sizes relating to different year-classes, A to E, are enclosed in separate arbitrary perimeters to represent the growth profiles of the respective year-classes. Although there are some differences in the modal sizes obtained at different places, which is to be expected, it is seen that, in general, the various modal groups can be aligned to the general pattern of growth seen at Calicut, although noticeable deviations are seen with the data of Mangalore for the period November 1964 to December 1965 relating to fish above 150 mm.

DISCUSSION

Hornell and Nayudu (1924) from their length frequency data on the oil-sardine for one year estimated a growth of 125 to 140 mm in 6 months, 155 to 170 mm for one year and about 190 mm for 2 years (the figures given by them in standard length are converted herein into total length to facilitate comparison). Generally their findings were that the spawning takes place at the end of first and second years of life. The disappearance of the fish in a few months after second spawning led the authors to the conclusion that the normal life span of the fish is 2½ years. These findings have been recently confirmed by Bensam (1968). Chidambaram (1950), on the other hand, inferred a life span of 3-4 years with an average length of 100, 145, 183, and 205 mm at the end of first to fourth years which found support in the findings of Nair (1953), who estimated 100, 150, 190 and 210 mm as the annual growth for the successive years. The contention of these two authors that the commercial fishery of immature fish that measure 100 mm or more is composed of one-year olds found agreement with the later workers like Sekharan (1965), Prabhu and Dhulkhed (1967), Sekharan and Dhulkhed (1968) and Bennett (1968) who adopted the same method of investigation.

The first detailed report is that of Chidambaram (1950) who although had reproduced the monthly length frequency distributions of different seasons, had based his conclusions on the annual percentage distribution for each season and not on the monthly progression of the modes. Since the annual picutre obtained by him showed three modal size groups, he presumed that these sizes represented the three successive year-classes and the average size for all the years was taken to represent growth during the first through fourth years. But the reason for considering the modal group around 100 mm as 1-year and not 0-year old was not established by him.

Balan (1968) concluded that the average lengths of 1, 2 and 3 year old fish are 130, 160 and 175 mm respectively based on the trimodal polygon of annual length frequency distribution. Based on the present data, the annual dominant size groups are shown in Table 4 for different seasons. If the assessment method of the above

TABLE 4. *The annual modal groups for various seasons*

Season	Annual modal group (mm)
1961—62	120, 160
1962—63	65, 120, 150, 165
1963—64	70, 95, 110, 155, 175,
1964—65	125, 180
1965—66	35, 105, 150, 185

workers were to be followed, the present study also will show 3 major modal groups 105-125, 150-165 and 175-185 mm, thus exhibiting the same pattern. But if the, weekly and monthly modal size progressions for the respective seasons are carefully looked into, it will become clear how the different smaller groups at 35, 65, 70 and 95 mm get shifted to 105-125 mm group as a result of rapid growth within three months and how the latter grow to 150-160 mm at the end of one year.

The conclusion of Sekharan and Dhulkhed (1968) that the sizes of one and two-year olds can be regarded as 100 and 150 mm respectively cannot be said to be authenticated by their data for, in most of the seasons they had to trace the growth only from 100 mm starting from September-October and presuming the age at recruitment as one year.

Prabhu and Dhulkhed (1967) maintained that the 100 mm group encountered during July-October of any year cannot represent the progenies of the same year's spawning. While they viewed the different modes of the juveniles seen in a particular month as resulting from two successive spawning seasons, Dutt (1968), without specifically indicating which of the two, considers that all come from the same spawning season.

Sekharan (1965) made one significant remark when he stated that the length frequency data suggested the possibility of there being two broods in a year. Following this observation, Sekharan and Dhulkhed (1968) recognised the presence of even four broods. The present study indicates that although there may be a maximum of four broods, normally only two register themselves strongly by virtue of thier greater numerical strength, and that they are recurits of the same year's spawning.

As against the observations of the above workers Bensam (1968) estimated a growth of 145-155 and 175 mm at the end of the first and second years respectively and suggested the possibility of some fish living up to three years. He has also observed a very fast rate of growth during the early juvenile phase with growth arrested from November to April but followed by a renewed activity up to August-September. These conclusions bear a very close similarity to those arrived at during the present investigation. Recently supporting evidence for the above view on the age has come from the work of Radhakrishnan (1969).

It has been seen that the differences in size ranges of the O-year-class are very wide during the first few months after recruitment (from August to October), after which they progressively get reduced. It is possible that this reduction is brought about as a result of growth compensation, a tendency for smaller fish to grow more rapidly than the larger fish of the same age group. Deason and Hile (1947) report such a growth compensation to be characteristic of most coregonids and cite several references where this phenomenon has been observed for other fishes. It is also seen that the period when the range is widest, August to October, is incidentally also the period of most rapid growth and, as Bayliff (1964) points out, it is virtually inevitable that when monthly data are pooled, the ranges of length distribution are wider for the months of rapid growth.

Since it has been shown in the present study that what constitutes the commercial fisery of juvenile sardine is O-year class, the success of the fishery depends on the strength of the incoming juvenile broods resulting from the major spawning in June to August period. If the spawning proves successful and if the survival rate of eggs and larvae is high, then, that season will be definitely marked by a successful fishery. Hence the fluctuations in the fishery are dependent on this rate of recruitment in the pre-exploited phase. It was indicated in an earlier investigation (Antony Raja, 1967) that due to pre-ovulation follicular breakdown resulting in large scale atresia in 1963 and the consequent reduction in the number of mature ova, there would have been poor spawning in that year. It was also predicted that if the 1963 season for juveniles should prove a failure, the causal factor can be traced to this physiological phenomenon. That, indeed, the 1963 season was a failure could be seen from the landings data (Prabhu. 1967). However, in the subsequent year, the fishery made a remarkable recovery, probably due to the high rate of egg production in the rapidly grown large-sized adults (170 mm and more at the end of first year) and high survival rate. In 1965 also a similar phenomenon of heavy follicular breakdown was observed. However, the 1965-66 season recorded a good catch, and as shown by Bennett (1968) the major share of this season's catch came from 150-160 mm group (group D of the present study).

As follicular breakdown in the gonads is likely to be caused by environmental factors it was decided to examine the amount of rainfall during the probable time of spawning. Since it is believed provisionally that spawning occurs during the darker phases of the moon, *i e.* a week before and after the new moon day, rainfall data for this period have been considered to find whether any trend is noticed suggesting that spawning is influenced by the rains (Table 5). It is interesting to see that in the

TABLE 5. *Rainfall in mm during spawning fortnights*

Year	Period	Rainfall	Daily average for the periods
1961	Jul 5 to Jul 19	592	36.1
	Aug 4 to Aug 18	492	
1962	Jun 24 to Jul 8	637	31.6
	Jul 24 to Aug 7	310	
	Jul 13 to Jul 27	122	
1963	Aug 12 to Aug26	387	13.0
	Sep 10 to Sep 24	76	
1964	Jun 3 to Jun 17	276	29.2
	Jul 2 to Jul 16	599	
1965	Jun 22 to Jul 6	305	18.3
	Jul 21 to Aug 4	245	

years 1961, 1962 and 1964, the average rainfall was about 30 mm or more whereas in 1963, it was the lowest, 13.0 mm and in 1965, the next lowest, 18.3 mm. As was pointed out earlier, during these two years follicular breakdown occurred on an extensive scale giving rise to the surmise that actual number of eggs spawned would have been considerably lower. Although any correlation at this stage with only limited data has to be attempted with due caution, the records do appear to indicate that the south-west monsoon and the resulting ecological conditions play a significant role in determining the recruitment.

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