FISHERY AND BIOLOGY OF THE OIL SARDINE AT KARWAR

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ABSTRACT

The oil sardine fishery at Karwar showed erratic fluctuations during the years of study, from an annual landing figure of 4.41 tonnes in 1964-65 to 250.06 tonnes in 1967-68. The average, based on the earlier 14 years' catch worked out to 91.21 tonnes. The three length frequency modes at 135-140, 160-165 and 185-190 mm have been interpreted to correspond to I, II and III age groups. The fish attains maturity at about 140 mm and the spawning season lasts from July-August to November-December. This is also supported by the trend of change in 'K' values. A good fishery season seems related to the temperature range of 27-29.5°C, lower salinity and a low phosphate content in the water.

INTRODUCTION

The fishery of the oil sardine showed a phenomenal revival during the last decade, as evidenced by the increased landings from 1957 onwards, along the west coast of India (Prabhu, 1967). The major share of the country's total oil sardine production comes from the two maritime states, Kerala and Mysore, and the present paper is based on a study of the oil sardine fishery at Karwar (Mysore) from 1964-65 to 1967-68 and on the hydrological factors influencing the fishery.

METHODS

The samples were collected from all the gear employed for the fishery *viz.*, 'rampan', 'yendi' (shore seines) and 'beesubale' (cast net). In 1965-66 season, purse seine was also in operation for two months, October and November. The estimations of effort, catch per unit effort (C/E) and numbers in any particular period were made according to the methods suggested by Sekharan (1962).

FISHERY

Table 1 gives the landings of oil sardine for 14 years at Karwar. It is clear from the table that 1955-'56, 1957-'58, 1960-'61 and 1964-'65 were lean years for the sardine fishery at Karwar. The 1962-'63 season had a record catch of all these years. Similarly, 1967-'68 recorded a very high catch after a lapse of five years. In between these years and earlier to the 1962-'63 season, the annual catch varied erratically. The average catch for Karwar during the 14-year period is of the order of 91.21 tonnes.

TABLE 1. *Total quantity of oil sardine landed at Karwar during the different seasons*

Seasons	Landings in tonnes	Seasons	Landings in tonnes
1954—55	179.29	1961—62	30.39
1955—56	0.04	1962—63	382.51
1956—57	72.78	1963—64	26.96
1957—58	—	1964—65	4.41
1958—59	113.81	1965—66	76.88
1959—60	118.73	1966—67	20.97
1960—61	0.09	1967—68	250.06

Tables 2 to 5 show the month-wise catch, effort and catch per unit effort (C/E) for the different gear for 1964-65 to 1967-68.

LENGTH-FREQUENCY STUDIES

According to earlier workers (Hornell, 1910; Devanesan, 1943; Nair, 1959) the oil sardine breeds during the period July to September. The spawning appears to be protracted for another two to three months, i.e., up to December, which is borne out by the occurrence of juveniles during December-January. It is also possible that more than one batch of eggs may be released during the spawning season which is evidenced by the presence of two or more adjacent modes of juveniles (Figs. 1 and 2). Owing to the prolonged nature of spawning and non-availability of mature specimens in the samples during the spawning season, it is rather difficult to establish the time interval between the shedding of the two batches of eggs. At the commencement of the season, the younger individuals form the mainstay of the fishery.

Fig. 1 represents the length frequency distribution of oil sardine for 1964-65 season when the fishery lasted for only two months, September and October. The

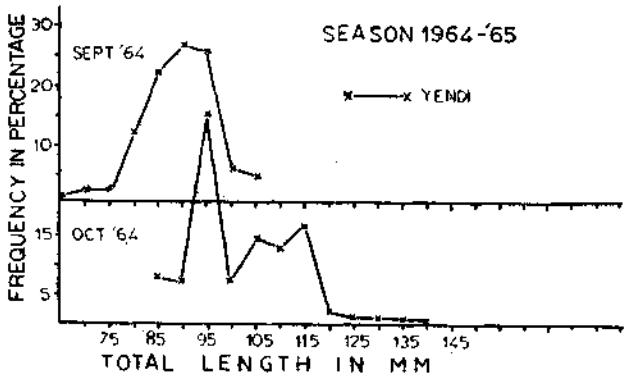

FIG. 1. Size frequency distribution of *Sardinella longiceps* in the commercial catches in 1964-65 season.

TABLE 2. *Catch and catch per unit effort for the year 1964 - '65*

Months	Yendi			Cast net			Total
	E	C	C/E	E	C	C/E	Catch (in kg)
Sep 1964	1577	132.5	0.08402	—	—	—	132.5
Oct	1185	4156.5	3. 5076	23	120	5.22	4276.5
Total	2762	4289.0	1.5520	23	120	5.22	4409.0

TABLE 3. *Catch and catch per unit effort for the year 1965 - '66*

Months	Rampan			Yendi			Cast net			Purse seine			Total catch
	E	C	C/E	E	C	C/E	E	C	C/E	E	C	C/E	(in kg)
Aug 1965	—	—	—	2304	1385	0.6011	—	—	—	—	—	—	1385.00
Sep	—	—	—	2096	4800	2.2901	90.5	480.0	5.3038	—	—	—	5280.00
Oct	2997.5	2850	0.9508	—	—	—	—	—	—	5	100	20	2850.00
Nov	11427.2	60830	5.3233	—	—	—	—	—	—	36	4755	132.08	60830.00
Dec	2930.0	125	0.0427	—	0.5	—	—	—	—	—	—	—	125.50
Jan 1966	10035.0	25	0.0025	—	—	—	—	—	—	—	—	—	25.00
Feb	3265.0	1500	0.4594	—	—	—	—	—	—	—	—	—	1500.00
Mar	—	—	—	—	—	—	—	—	—	—	—	—	—
Apr	—	—	—	—	—	—	—	—	—	—	—	—	—
May	—	—	—	1922	25.0	0. 013	—	—	—	—	—	—	25.00
Jun	—	—	—	—	—	—	—	—	—	—	—	—	—
Jul	—	—	—	3187	10.0	0.0031	—	—	—	—	—	—	10.00
Total	30654.7	65330.0	2.1311	9509.0	6220.0	0.6542	90.5	480.0	5.3038	41.0	4855	118.14	76885.50

E—Effort in man hours; C—Catch in kg; C/E—Catch per unit effort in kg.
In case of purse seine, catch per unit effort is expressed in terms of catch per haul.

TABLE 4. *Catch and catch per unit effort for the year* 1966 - '67

Month	Rampan			Yendi			Cast net			Total catch
	E	C	C/E	E	C	C/E	E	C	C/E	(in kg)
Aug 1966	—	—	—	3356	3170.00	0.9446	—	—	—	3170.00
Sep	—	—	—	1799	8000.00	4.4450	330.0	1800	5.4545	9800.00
Oct	—	—	—	—	1.00	—	—	—	—	1.00
Nov	—	0.254	—	—	—	—	—	—	—	0·254
Dec	—	—	—	—	—	—	—	—	—	—
Jan 1967	3617.5	8000.00	2.2115	—	—	—	—	—	—	8000.00
Feb-Jul	—	—	—	—	—	—	—	—	—	—
Total	3617.5	8000.25	2.2115	5155	11171.00	2.1670	330.0	1800	5.4545	20971.254

TABLE 5. *Catch and catch per unit effort for the year 1967 - '68*

Month	Rampan			Yendi			Cast net			Total catch
	E	C	C/E	E	C	C/E	E	C	C/E	(in kg.)
Aug 1967	—	—	—	—	—	—	—	—	—	—
Sept	—	—	—	2185	1121.30	0.5135	228	740.0	3.2456	1861.30
Oct	21942.5	1200.35	0.0547	—	—	—	20	180.0	9.0	1380.35
Nov	18175.0	75000.00	4.1265	22	5.00	0.23	104	515.0	4.925	75520.00
Dec	19002.5	110050.00	5.7913	—	—	—	24.5	135.0	5.5102	110185.00
Jan 1968	5835.0	61000.00	10.4541	186	120.00	0.6451	—	—	—	61120.00
Feb-Jul	—	—	—	—	—	—	—	—	—	—
Total	64955.0	247250.35	3.8064	2393.0	1246.30	0.5208	376.50	1570.0	4.17	250066.65

E—Effort in man hours; C—Catch in kg; C/E—Catch per unit effort in kg.
In case of purse seine, catch per unit effort is expressed in terms of catch per haul.

modes at 90 mm and 105 mm in August 1965 (Fig. 2), which could not be traced in the preceding months owing to non-availability of catches, may represent the progeny of the late spawners. The group at 90 mm modal length can be traced at 125 mm in November and 135 mm in December 1965. The mode at 105 mm in August can be traced at 115 mm in September. The group at 135 mm in December 1965 may represent the progeny liberated a year earlier.

Prabhu and Dhulkhed (1967) have reported small-sized oil sardine, 40-50 mm in length, in large numbers during August-October. These, then, disappear from the fishery and the medium-sized fish ranging 120-150 mm in size dominate the catches. On the assumption that spawning has taken place in June-July period these small-sized individuals are probably a few months old.

The group, therefore, which is represented by the modes at 105 mm and 115 mm in December 1965 and January 1966 respectively (Fig. 2) might have originated from the spawning of July-August 1965, and may further grow to 140 mm modal length in August/September 1966 (Fig. 3). This group was absent from the fishery from February to July 1966. From the above observations, it is reasonable to deduce that the species attains a size of about 135-140 mm at the end of the first year of its life.

Assuming that spawning has taken place in July-August 1964, the mode at 145 mm in October and November 1965 may be taken to represent fish which are more than a year old. This group can be traced at 150, 155 and 155 mm in December 1965, January and February 1966 respectively. The same group again makes its appearance in July 1966 at 160 mm as two-year old fish. In September 1965, the group at 160 mm may represent the brood liberated two years earlier. Similarly, the group at 160 mm in December 1965 and at 165 mm in January and February 1966 may be the recruits spawned during December 1963 - January 1964 (Fig. 2).

The modes at 170 mm (Fig. 3) in August 1966 and January 1967 which represent fish more than two - year old (with a difference of four months in between) may have originated from the corresponding spawners of the 1964 season. The mode at 145 mm in January 1967 comprises fish, more than one year old, from the spawning of 1965. The modes at 105, 115 and 120 mm in September, October and November 1966 respectively could not be traced in the succeeding months. In 1967-68 season (Fig. 4), the mode at 125 mm in September, 130 mm in October and 135 mm in November 1967 represent the 1966 year-class showing the progression of the mode, in an year's growth. It is not observed in the subsequent months. Similarly the mode at 115 mm in September may be traced at 125 mm in November and at 130 mm in December 1967. The group at 110 mm in October 1967, representing the 1967 year-class, may further be traced at 125 mm in January 1968. The group at 95 mm in both November and December 1967 and at 100 mm in January 1968 could not be traced further as there was no fishery in the succeeding months.

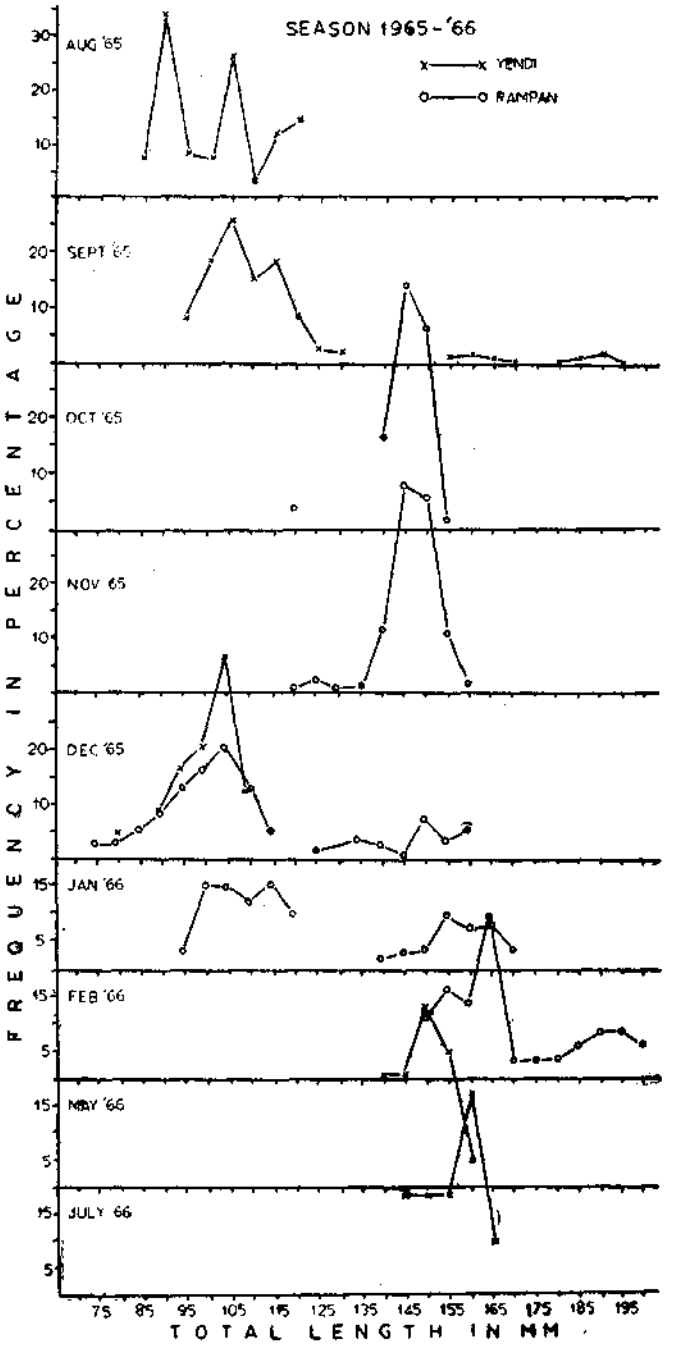

FIG. 2. Size frequency distribution of *S. longiceps* in the commercial catches in 1965-66 season.

In September 1965, February 1966 and December 1967 the older groups at 190, 190-195 and 185 mm represent the 1962, 1963 and 1965 year-classes respectively. The mode at 170 mm in January may be traced at 185-190 mm in December 1967, which probably represents three-year old fish. From the present study it is deduced that the average range of lengths attained by the fish at the end of the first, second and third year of life are 135-140 mm, 160-165 mm and 185-190 mm respectively.

The year-classes entering the fishery during the different seasons are summed up as follows:

Season	Oil sardine catch of the season (kg)	Percentage contribution by different year classes by weight and by numbers in parentheses					
		1962	1963	1964	1965	1966	1967
1964—65	4409.00	—	—	100 (100)	—	—	—
1965—66	76885.50	0.17 (0.07)	0.92 (0.46)	89.06 (76.06)	9.85 (23.41)	—	—
1966—67	20971.25	—	—	6.28 (7.24)	57.70 (31.01)	36.01 (61.75)	—
1967—68	250066.65	—	—	—	0.06 (0.06)	5.03 (4.85)	94.91 (95.09)

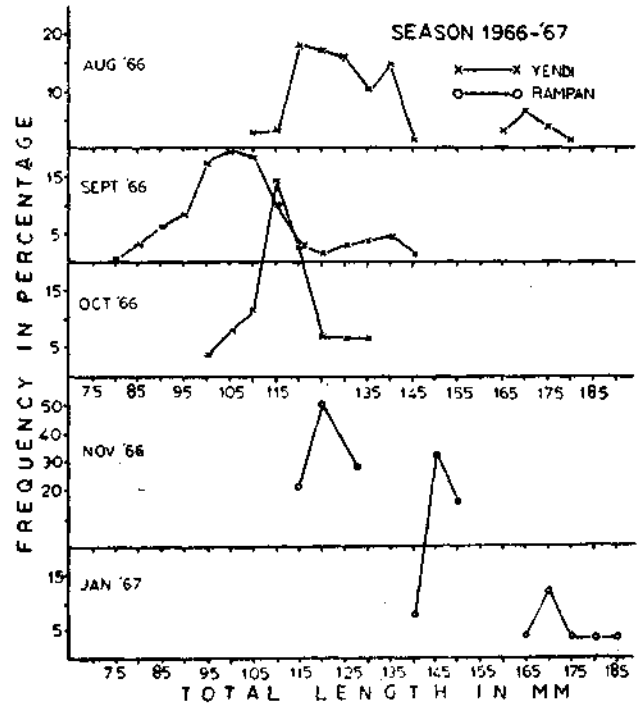

FIG. 3. Size frequency distribution of *S. longiceps* in the commercial catches in 1966-67 season.

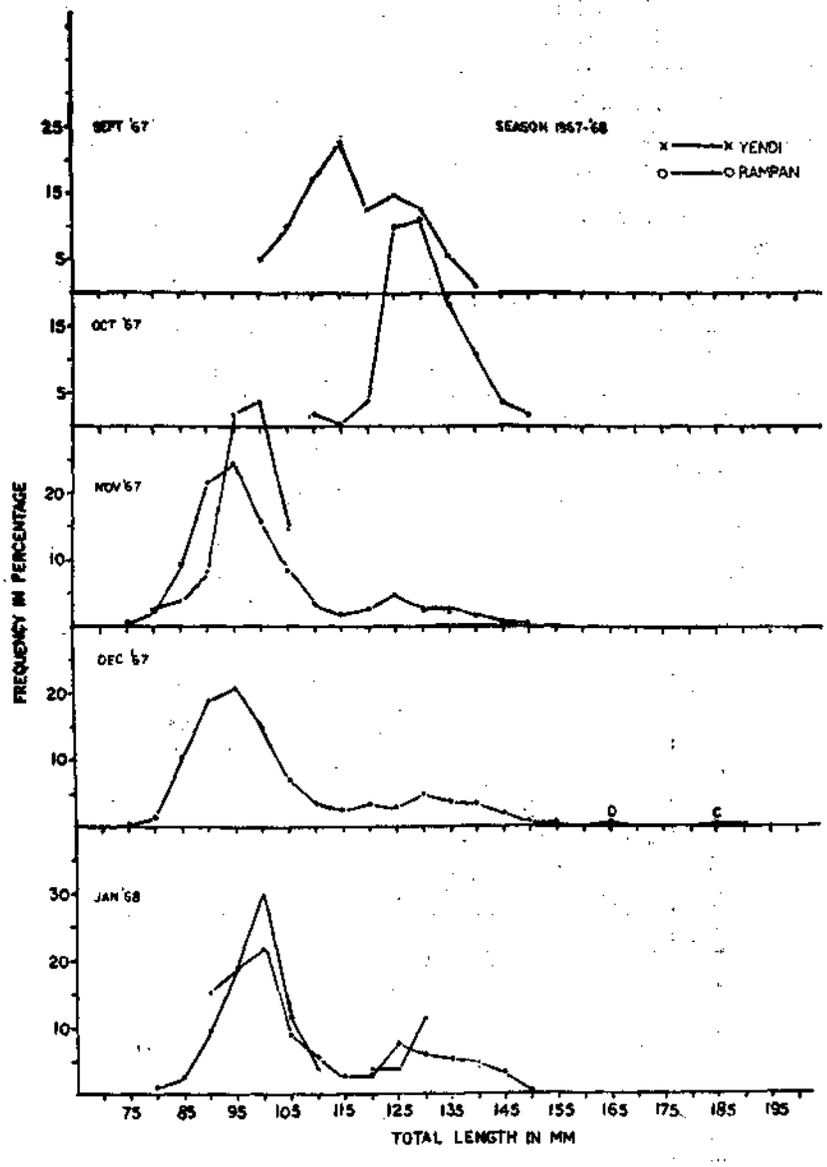

FIG. 4. Size frequency distribution of *S. longiceps* in the commercial catches in 1967-68 season.

LENGTH-WEIGHT RELATIONSHIP

To obtain the length-weight relationship of oil sardine, about 509 fish, ranging 74 - 199 mm in length and 3.3-56.1 g in weight, taken from the 'rampan' catches, were studied. The lengths and weights were converted into logarithmic forms for

this purpose. The exponential form of length-weight formula $W=aL^n$ was adopted. When the log values were used this assumed the form

$$\text{Log } W=a+n \text{ log } L$$

where W is the weight of fish in grams, L is the length of fish in mm, a is a constant and n is the regression coefficient. Fig. 5 (A-C) shows a straight line relationship of regression of weight on length in respect of males, females and unsexed fish. The regression coefficients for males, females and unsexed fish were calculated separately by the least squares method. The equations thus derived are given below:

Males:	$\text{Log } W=\bar{6}.5548+3.1729 \text{ Log } L$
Females:	$\text{Log } W=\bar{7}.8442+3.5034 \text{ Log } L$
Unsexed fish:	$\text{Log } W=\bar{5}.1305+2.8762 \text{ Log } L$
Average:	$\text{Log } W=\bar{6}.6172+3.1890 \text{ Log } L.$

The standard error of estimate (S_{yx}) was calculated for males and females. In case of unsexed juveniles, which were fewer in number, these errors were not estimated. The standard deviations for males and females (S_{yx}) of sample points from the estimated regression line were found to be 0.02941 and 0.0566 respectively. The sample standard error of the regression coefficient (sb) for males was 0.3275 and for females, 0.0537.

Spawning Behaviour

To determine the nature of spawning and spawning periodicity, a study on the ova-diameter measurements of ripe ovaries was made. Fig. 6 represents the combined frequency curves of intraovarian eggs at different stages of maturity from stage II onwards. Ovaries of stages II and III show a single batch of maturing eggs withdrawn from the general egg stock. The ovary in stage IV also shows, in addition to the mature batch of eggs, two more maturing batches. In ovaries belonging to the stages IV+ and V, the ova diameter ranges are 0.017—0.714 mm and 0.017—0.765 mm respectively. Mature individuals ranging in size 173-192 mm were collected in September 1965, and with a size range 145 - 158 mm in May 1966. The availability of mature specimens from May to September naturally indicates the prolonged nature of spawning in this species. From the analysis of monthly catch data, it is seen that it is a rare event to obtain mature individuals during the spawning season. Only two seasons out of these years showed mature individuals in advanced stages of maturity; for the rest of the years, the females obtained during the spawning season were in maturity stages I and II. Therefore, there is every reason to suppose that this species goes to the offshore regions, beyond the limit of presently exploited fishing grounds, for spawning. In the ovaries of stage V, the mature batch of ova, separated from the immature oocyte and maturing batch, shows a wide range.

In May 1966, females in stages of maturity II to V were collected and they had a size range of 145-158 mm. Stages II and III showed a similar pattern of the

distribution of ova as in Fig. 6. But the fishes with their ovaries in stage V, possess two batches of mature eggs which probably will be shed in the ensuing season. The ovaries of fishes ranging in size 173-193 mm were characterised by their blood-shot appearance. These were collected in September 1965. Spent individuals of 196 - 199 mm were observed in January and February, and these had small intra-ovarian eggs, along with a few large, residual eggs in between. Fishes measuring 173 and 185 mm showed a single batch of mature eggs and two batches of maturing

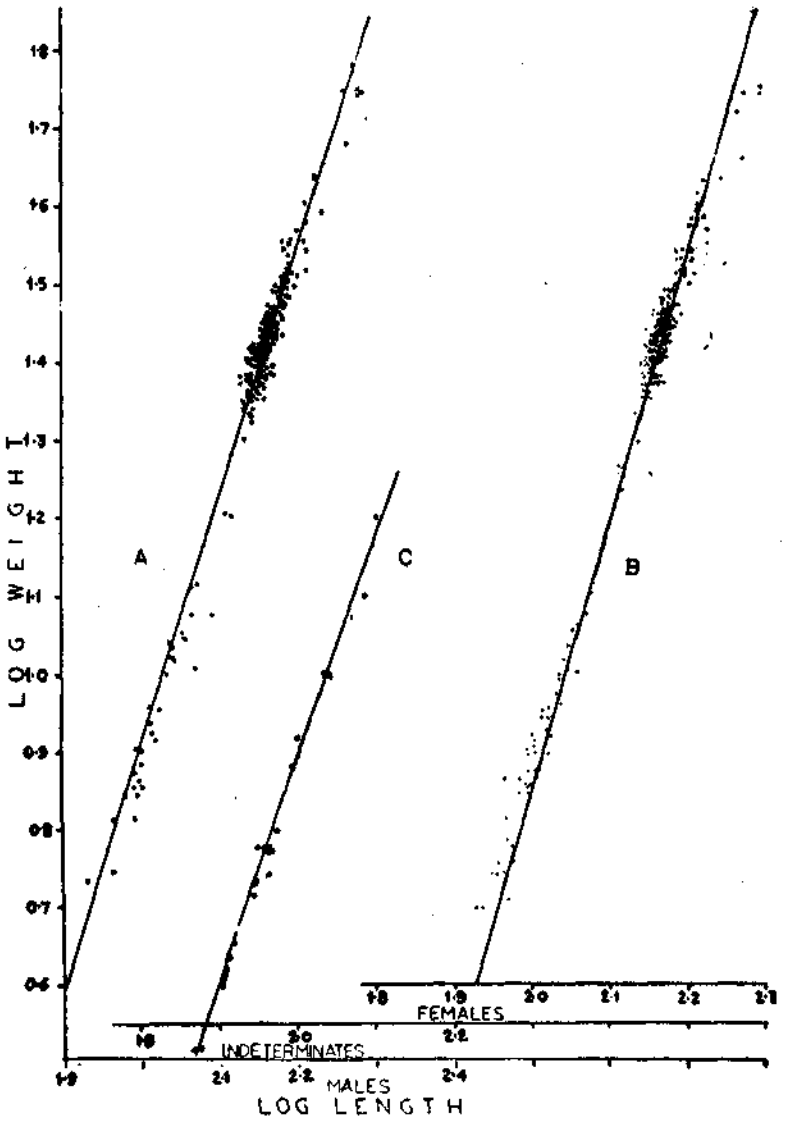

FIG. 5. Regression of log. weight on log. length of males (A), females (B) and indeterminates (C).

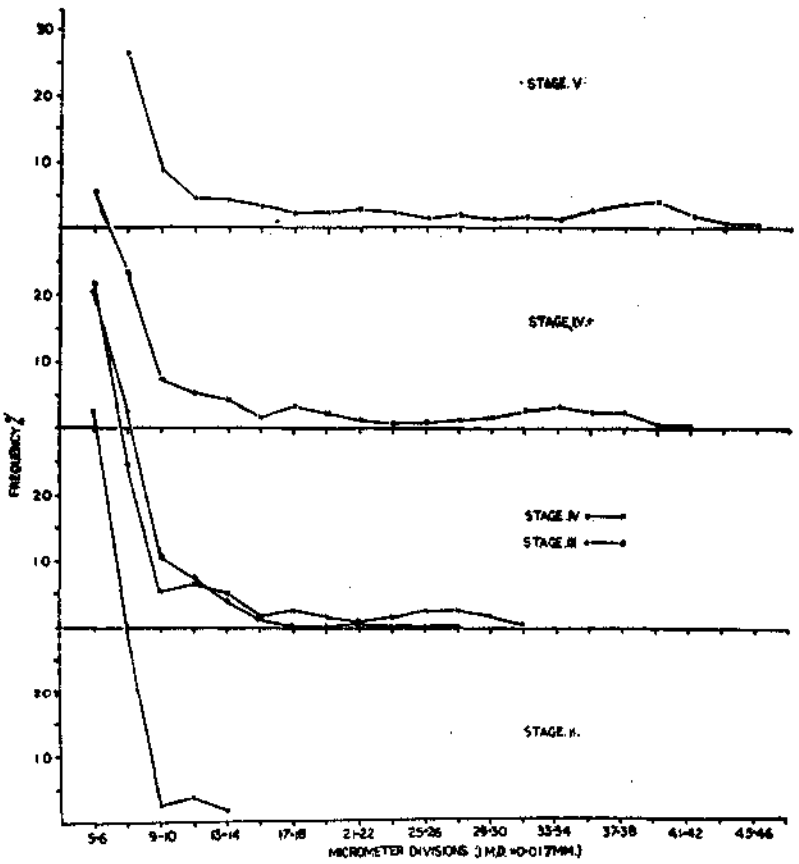

FIG. 6. Combined ova-diameter frequency polygons of ovaries of *S. longiceps* in different stages of maturity.

eggs. But the fish measuring 192 mm length showed more than one batch of mature eggs. The fish measuring 184 mm length also showed the tendency of having two batches of mature eggs. From the above account it is clear that this species shows a protracted spawning lasting from June to November or December, or perhaps even longer.

PONDERAL INDEX

Several workers (Menon, 1950; LeCren, 1951; Pillay, 1954; Sarojini, 1957) have correlated the ponderal index or coefficient of condition with the attainment of maturity, feeding intensity and the spawning behaviour of a fish. They expressed the relative condition 'Kn' as the ratio of the observed weight (W) to the smoothened mean weight ($\hat{w}$) i.e. $Kn = W/\hat{W}$. In the present study the ponderal index was calculated by the formula used by Hickling (1930). It is expressed as $K = 100\ W/L^3$

where, W is the weight of fish in grams, L is the length of fish in cm and K is the condition factor to be calculated for each length group. The total number of males and females used for this study were 371 and 457 respectively.

Tables 6 and 7 give the fluctuations in the K values during different months and the average K value from each length group.

TABLE 6. *Ponderal index values in different months*

Months		Average monthly 'K' values	
		Males	Females
September	1965	1.0275	1.0150
October	1965	0.8856	0.8547
November	1965	0.8676	0.8699
December	1965	0·9131	0.8367
January	1966	0.8680	0.9265
February	1966	0.8389	0.8113
May	1966	0.8908	0.9024
July	1966	0.7823	0.7695
August	1966	0.9492	0.9191

TABLE 7. *Ponderal index values in different length groups*

Average length in cm	Average 'K' values	
	Males	Females
8.0	0.7617	0.7164
9.0	0.7979	0.7782
10.0	0.7828	0.8271
11.0	0.7875	0.7987
12.0	0.8109	0.8106
13.0	0.8453	0.8405
14.0	0.8734	0.8584
15.0	0.8626	0.8667
16.0	0.8851	0.8687
17.0	0.9084	0.8834
18.0	0.8732	0.8920
19.0	0.9008	0.8578
20.0	0.8247	—

It will be seen from Table 7 that the first higher value for males and females is observed at 9 and 10 cm respectively. The K value in both sexes goes on increasing, reaching maximum at 14 cm, followed by a fall at 15 cm and rises again after 15 cm. If the point of inflexion on the curve showing the low condition is taken

to mark the size at first maturity, then 14-15 cm represents that size. This is also supported by the fact that the fish in advanced stage of maturity had a size range 145 - 158 mm.

Hydrological Conditions and the Oil Sardine Fishery

Chidambaram (1950) observed a good oil sardine fishery when the temperature values were below 29° C. Sekharan (1962) in 1957-58 observed good landings at Calicut when the average temperature and salinity values ranged 28.5 - 29.9° C and 33.08 - 35.04‰ respectively; and in those years when these limits were exceeded poor fishery was the result. With a view to correlate the fishery and hydrological conditions prevailing at Karwar the data in respect of temperature, salinity, dissolved oxygen, plankton volume and the phosphate content of the water, collected during the different months, were utilised.

The noteworthy period was from October to December - January which showed a rich fishery with peak landings in November or December.

In 1964 - 65, the period from September to May showed a gradual increase in temperature from 25.99 to 30.13°C with the salinity variations 19.64 - 35.68‰ in the surface waters. The fishery was for only two months and the temperature and salinity were found to be 25.99°C, 19.64‰ and 25.32°C, 20.13‰ respectively. In all the other months, up to February 1965, the temperature was approximately 27°C and the salinity values below 34.6‰ in surface waters. The dissolved oxygen content showed a steady decline from August to December 1964 and increased again slightly from January to March 1965. The month of October alone showed better catches than those of the previous months. During October the plankton volume was lower than in the following months.

In the next season, September-December recorded better catches than other months. The peak was noticed in November 1965. The temperature and salinity ranged 26.54 - 29.02°C and 18.05 - 33.55‰ at the surface. Dissolved oxygen showed a gradual decrease from August to December, with low values in the middle and bottom layers. Similarly, the plankton volume was high in September and October and decreased to 4.86 ml in November during which month the maximum catch for this season was recorded. There was again a rise in plankton volume during the following months when the fishery was poor. During November when the catch amounted to 65.5 tonnes, the temperature varied from 29.02 to 29.46°C and salinity 33.55 to 34.75‰, from surface to deeper layers.

During 1966-67 fishing season the fishery was poor. Only three months, August, September and January, showed slightly better catches. During these months the temperature and salinity in surface layers varied from 26.80 to 27.30°C and 12.94 to 32.37‰ respectively. The temperature never exceeded 27.5°C during these months. The volume of plankton in August was the maximum when the catch was roughly 3.0 tonnes. In the next month when the catch showed an increase the

volume of plankton decreased. The plankton volume again increased up to December, decreasing again in January with an increase in the sardine catch. The subsequent months which recorded more plankton volume showed no sardine catch.

The 1967-68 season which showed the record catch of 250 tonnes started in September and closed in February. Of this period, November to January contributed the major share of the catches showing the peak catch in December 1967. During these months temperature showed a lower range from 25.56 to 26.92°C and salinity from 33.78 to 34.52‰ at the surface. The dissolved oxygen showed gradual decrease from August up to January and an increase thereafter. The plankton volume was high from August to October, declined to 2.82 ml in November, rose to 5.5 ml in December and 5.6 ml in January 1968, when the catches were high. Therefore, in all these years there appears to be an inverse relationship between the sardine catch and the volume of plankton.

It is of interest to mention here that Subrahmanyan (1959) observed an inverse relation between the phosphate content and sardine landings. It has been observed at Karwar also that as the content of phosphate in water decreased the sardine catch increased. The following table shows the correlation of sardine landings and mean phosphate and rainfall values for the four successive years.

TABLE 8. *Correlation between oil sardine landings and mean phosphate and rainfall values*

Years	Mean values of inorganic phosphates (μg at/l)	Oil sardine landings in tonnes	Rainfall (inches)
1965—66	Surface : 0.5189		
(May-April)	Middle : 0.5768	76.88	91.6
	Bottom : 0.6986		
1966—67	Surface : 0.5015		
(May-April)	Middle : 0.5720	20.97	120.8
	Bottom : 0.6599		
1967—68	Surface : 0.4855		
(May-April)	Middle : 0.5303	250.06	118.0
	Bottom : 0.6216		
1968—69	Surface : 0.3879		
(May-March)	Middle : 0.4733	602.27	108.4
	Bottom : 0.5942		

DISCUSSION

According to Nair (1953), the oil sardine attains average sizes of 10, 15 and 19 cm at the end of the first, second and third years respectively. Approximately the same growth rates have been observed by Sekharan (1962). Balan (1968) indicated that the fish grows to 14.3, 16.4 and 18.6 cm at the end of the first, second and third

years of its life, based on his studies at Calicut and Cochin. Radhakrishnan (1968) stated that the modal size range of one-year old fish appeared to be 135 - 145 mm and that of the second year, 160 - 165 mm. As the length frequency studies also indicated that the juvenile phase of the life cycle has a rapid growth the estimate of 135 - 140 mm growth at the end of the first year appears to be quite reasonable. In the second and third years of life the fish shows very slow growth. Sekharan (1962) in his length frequency studies on the oil sardine has indicated the possibility of two broods in one year. The present study at Karwar lends support to this observation. The major contribution to the fishery at Karwar is from 0 and 1+ age groups, almost similar to what has been shown in other regions of the south-west coast of India.

Regarding the minimum size at first maturity also there are some divergent opinions. Hornell and Nayudu (1924) and Devanesan (1943) have stated that the oil sardine attains a size of 150 mm at first maturity. Dhulkhed (1964) assessed the size at first maturity as 165 - 169 mm. Radhakrishnan (1968) has shown that the minimum size at first maturity is around 120 - 139 mm. At Karwar fish in advanced stages of maturity were observed in the size range of 145 - 158 mm. This is an indication that the maturity sets in when the fish is smaller than 145 mm. Furthermore, the changes in K values show that the maturity occurs in fishes of about 140 mm in length.

The spawning season in this fish appears to last for several months. Probably more than one batch of eggs become mature and are shed in several bits. According to Antony Raja (1964), although two batches of eggs get differentiated towards maturation, the more advanced group of ova is shed during the spawning season and the second batch of ova is retained after the spawning in a partially-spent condition, which probably gets absorbed subsequently. But as the species shows two mature batches of eggs very close to each other it is quite likely that the second batch of mature eggs is also spawned and the maturing batch may be resorbed subsequently.

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