

SEX RATIO AND MATURITY STAGES OF THE OIL SARDINE, *SARDINELLA LONGICEPS* VAL., FROM THE MANGALORE ZONE

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ABSTRACT

Determination of sex ratio of the oil sardine during the period of 7 years, 1960—67, showed that there is not much difference in the ratio of the two sexes during the fishing seasons and the apparent variation which is seen from month to month is probably due to inadequacy in sampling. Disparity in sex ratio in one-year class in most years and equality of both the sexes among the two-year old fishes have been recorded. The occurrence of oil sardine at different stages of maturity has been determined. Active spawning seems to occur from June to September.

INTRODUCTION

Earlier workers (Chidambaram 1950; Nair, 1952, 1959; Sekharan, 1962) have mainly dealt with the fishery and certain biological aspects of the oil sardine. Investigations on the sex ratios of *Sardinella longiceps* were initiated at Mangalore and the data pertaining to the years 1960-67 have been presented in this paper. In addition to this, observations made on the distribution of various maturity stages of the oil sardine during the different months of these seven years, which throw light on the spawning period, have also been included.

MATERIAL AND METHOD

Oil sardine caught by fishing vessels using various types of gears at different fish landing centres, between Malpe in the north and Kasargod in the south, formed the basis of the present study. From the samples obtained it can be assumed that there was no bias in the capture of the two sexes by the gears used, throughout the Mangalore zone. The fishes were sexed and their maturity stages were determined. The stages of maturity referred to in this paper correspond to those given by the International Council for the Exploration of the Sea except that the oil sardines in partly spent condition were similar to those at stage VIIa. In the course of these investigations, oil sardines depicting maturity stage VI were not encountered in the catches.

SEX RATIO

Table 1 gives the numbers of both sexes. It can be seen from the table that in most months females outnumbered the males except in some months when the two sexes were almost equally distributed. The preponderance of females particularly during July-October is of special interest, since this period coincides with the reported spawning season of the oil sardine.

To see whether the two sexes are in the same proportion or whether there is any significant difference between the two, the following statistical procedure was applied.

$$\chi^2 = \frac{1}{pq} \left\{ \sum (ap) - n\bar{p} \right\}$$

where, p = proportion of males in the monthly samples,
 a = the number of males in the monthly samples.
 \bar{p} = proportion of males in the composite sample as a whole.
 n = the number of males in the composite sample as a whole.
 $\bar{q} = 1 - \bar{p}$.

The χ^2 values and their associated D.F. and the corresponding probability limits for getting a higher χ^2 for the various years are given in Table 2.

At probability level of 0.05 the χ^2 values for the years 1962-63, 1963-64, 1965-66 and 1966-67 are significant. But they are not significant at the probability level of 0.01. Therefore, it can be concluded that the same sex ratio is being maintained throughout the year and the variations which are noticed in the monthly sex ratios are due to errors in sampling.

Another point of interest was to ascertain whether both the sexes are equally distributed every month, for which the data given in Table 1 were further analysed by the usual χ^2 test.

$$\chi^2 = \frac{\sum (O - E)^2}{E}$$

where, O = actual observed numbers of males and females.

E = expected number of males and females according to the hypothesis 1:1.

The χ^2 values and their associated D. F. and the corresponding probability limits for getting a higher χ^2 for the various years are given in Table 3.

Since $p < 0.05$ for the years 1961-62, 1963-64, 1964-65, 1965-66 and 1966-67, it may be concluded that the hypothesis of equal sex ratio does not hold good. But in 1960-61 and 1962-63, it is seen from Table 3 that $p > 0.05$, thereby indicating that the deduction of both sexes being in equal number seems valid.

TABLE 1. Sex ratio of oil sardine during 1960-61 to 1966-67

Months	1960-61			1961-62			1962-63			1963-64		
	Sample size	Males	Ratio	Sample size	Males	Ratio	Sample size	Males	Ratio	Sample size	Males	Ratio
July	50	23	0.46	..	..	..	121	72	0.60	..	..	..
August	143	64	0.45	142	72	0.51	55	25	0.45	Data inadequate		
September	245	111	0.45	51	16	0.31	29	15	0.52	Indeterminates		
October	323	166	0.51	..	..	..	..	..	..	118	67	0.57
November	113	41	0.36	117	47	0.40	129	67	0.52	Indeterminates (a few samples not sexed)		
December	165	84	0.51	123	53	0.43	197	104	0.53	43	22	0.51
January	147	77	0.52	87	37	0.42	206	98	0.48	78	34	0.44
February	..	..	..	103	48	0.47	138	64	0.46	217	90	0.41
March	51	24	0.47	40	20	0.50	60	36	0.60	134	60	0.45
April	88	44	0.50	64	34	0.53	40	19	0.48	..	..	..
May	..	..	..	..	..	..	..	..	..	..	..	..
June	..	..	..	..	..	..	..	..	..	..	..	..
Total	1325	634	0.48	727	327	0.45	975	500	0.51	590	273	0.46

TABLE 1. (Continued)

Years	1964—65			1965—66			1966—67		
	Sample size	Males	Ratio	Sample size	Males	Ratio	Sample size	Males	Ratio
July	50	15	0.30	41	13	0.32	..	..	..
August	25	8	0.32	114	43	0.38	263	130	0.49
September	25	8	0.32	160	79	0.49	107	56	0.52
October	50	23	0.46	167	77	0.46	181	85	0.47
November	20	12	0.60	326	148	0.45	365	139	0.38
December	87	48	0.55	268	109	0.41	287	102	0.35
January	58	27	0.47	140	64	0.46	132	50	0.38
February	164	76	0.46	150	62	0.41	294	125	0.42
March	186	75	0.40	301	129	0.43	131	62	0.47
April	30	10	0.50	254	110	0.43	102	46	0.45
May	115	50	0.43	125	54	0.43	113	41	0.36
June	..	..	..	..	..	..	61	24	0.39
Total	800	352	0.44	2046	888	0.43	2036	860	0.42

TABLE 2. χ^2 values for 1960-67

Years	D. F.	Value of χ^2	Probability of χ^2
1960 - 61	8	2.36	0.95 < p < 0. 97
1961 - 62	7	9.05	0.10 < p < 0. 25
1962 - 63	8	17.65	0.01 < p < 0. 02
1963 - 64	4	10.82	0.02 < p < 0. 05
1964 - 65	10	12.46	0.01 < p < 0. 25
1965 - 66	10	20.11	0.02 < p < 0. 05
1966 - 67	10	22.78	0.01 < p < 0.025

TABLE 3. χ^2 values for 1960 - 67

Years	D. F.	Value of χ^2	Probability of χ^2
1960 - 61	8	13.70	0. 05 < p < 0. 10
1961 - 62	7	16.62	0. 01 < p < 0.025
1962 - 63	8	9.38	0. 25 < p < 0. 50
1963 - 64	4	13.94	0.005 < p < 0. 01
1964 - 65	10	26.62	p < 0.005
1965 - 66	10	44.02	p < 0.005
1966 - 67	10	72.44	p < 0.005

LENGTH GROUPS AND SEX RATIO

For this study, the oil sardines were grouped in larger length range, viz., up to 99 mm, 100-149 mm, 150-189 mm and 190-214 mm (Table 4). This was based on the assumption that the oil sardine attains the lengths of 10, 15 and 19 cm during the 1st, 2nd and 3rd year of its life (Chidambaram 1950; Nair, 1952; Sekharan, 1962; Sekharan and Dhulkhed, 1967).

As explained earlier, the χ^2 test was also applied to each group in each year and for all the groups for the different years combined to see whether the sex ratio departs significantly from the expected ratio of 1:1. It is seen from Table 5 that in 100-149 mm length group $p > 0.05$ in 1960-61, 1962-63 and 1963-64. This suggests that both males and females were equally distributed. But in the years 1961-62, 1964-65, 1965-66 and 1966-67, $p < 0.05$ indicating that in this length group the females outnumbered the males. In other words, the changes in the sex ratio indicate a differential distribution of the sexes during different years. In 150-189 mm length group the value of χ^2 at probability level of 0.05 was found to be significant for 1963-64, 1965-66 and 1966-67 indicating that the two sexes in these years were almost equally distributed in the population. In the last group, viz., 190-214 mm, the χ^2 values at 0.05

probability level were not significant except for the year 1964-65 and 1966-67, thus, suggesting that the occurrence of both the sexes is in the same proportion during these years.

DISTRIBUTION OF MATURITY STAGES

The data on the occurrence of various maturity stages of the oil sardine in different months during the years 1960 to 1967 have been given in Table 6. It can be seen from the table that in the population, the percentages of oil sardine in various stages vary from month to month. From July to September, the bulk of the catches included mainly the spawners (maturity stage V). The percentages of oil sardine at stage V in commercial catches during July 1962, 1964 and 1965 were 77.0%, 100.0% and 68.3% respectively. In August 1960, this stage was 61.9%, whereas in August 1961 it was 91.0%. In September 1960, 1961, 1962 and 1965, the oil sardine in stages V were recorded in smaller percentages. The occurrence of oil sardine in higher stages of maturity including the spent stage from July to September indicates that probably spawning occurs during this period. From July to October, the oil sardine in various degrees of spent condition contribute to the fishery of small magnitude. In August 1964, the oil sardine in stage VIIa was 100% and this probably can be attributed to inadequate sampling. A significant feature noticed was the occurrence of spent (stage VII) oil sardine in the catches almost throughout the 1965-66 and 1966-67 seasons. They belonged to the larger size groups (160-189 mm) and their contribution to the total catch was fairly high during these two years.

Usually during August-October, indeterminates (sexes not distinguishable) enter and dominate the fishery. In August 1965 and 1966, the indeterminates amounted to 86.7% and 78.1% respectively. In September 1961, 1962, 1964, 1965 and 1966, the contribution of indeterminates to the catches was 82.2%, 89.6%, 89.0%, 85.1% and 88.7% respectively. Indeterminates dominated the catches in October 1964 and also in November 1963 and 1964.

From October to February, the oil sardine fishery in the Mangalore zone was mainly supported by the immature fish (stage I and II) and they showed large fluctuations from month to month in their percentages. Oil sardine in maturity stage III made their appearance in the catches in September-October, but a gradual increase in their percentages was noticed in March and April. Oil sardine at stage IV were usually observed from April to September. In May 1966, the oil sardine at stage IV formed 69.6% of the catch. Oil sardine at stage V were also recorded during the same month of the years 1966 and 1967, which indicates that the spawning may, perhaps, commence in June.

Based on the pattern of distribution of various maturity stages it appears that the maturation of gonad is slow during the early stages (I and II) and possibly takes 4-5 months. From stage III onwards the growth of gonads seems to be quicker and the time taken to attain stage IV and stage V in each case is approximately 2-3 months.

TABLE 4. Sex ratio in different length groups

Years	Total			up to 99 mm			100-149 mm			150-189 mm			190-214 mm		
	Males	Females	Ratio of males	Males	Females	Ratio of males	Males	Females	Ratio of males	Males	Females	Ratio of males	Males	Females	Ratio of males
1960-61	634	691	0.48	6	7	0.46	402	420	0.49	214	247	0.46	12	17	0.41
1961-62	327	400	0.45	—	—	—	88	133	0.40	237	263	0.47	2	4	0.33
1962-63	500	475	0.51	—	—	—	249	214	0.54	239	246	0.49	12	15	0.44
1963-64	273	317	0.46	—	—	—	118	99	0.54	154	215	0.42	1	3	0.25
1964-65	352	448	0.44	—	—	—	178	241	0.42	153	168	0.48	21	39	0.35
1965-66	888	1158	0.43	—	—	—	146	215	0.40	705	893	0.44	37	50	0.42
1966-67	860	1176	0.42	—	—	—	179	355	0.33	677	809	0.46	4	12	0.25
Total	3834	4665	0.45	6	7	0.46	1360	1677	0.45	2379	2841	0.46	89	140	0.39

TABLE 5. χ^2 values for different length groups

Years	up to 99 mm		100-149 mm		150-189 mm		190-214 mm	
	χ^2	P	χ^2	P	χ^2	P	χ^2	P
1960-61	0.08	0.75 < p < 0.90	0.40	0.50 < p < 0.75	2.36	0.10 < p < 0.25	0.86	0.25 < p < 0.50
1961-62	..	..	9.16	p < 0.005	1.36	0.10 < p < 0.25	0.66	0.25 < p < 0.50
1962-63	..	..	2.64	0.10 < p < 0.25	0.10	p < 0.075	0.34	0.50 < p < 0.75
1963-64	..	..	1.66	0.10 < p < 0.25	10.08	p < 0.005	1.00	0.25 < p < 0.50
1964-65	..	..	9.48	p < 0.005	0.70	0.25 < p < 0.50	5.40	0.01 < p < 0.025
1965-66	..	..	13.18	p < 0.005	22.12	p < 0.005	1.94	0.10 < p < 0.25
1966-67	..	..	58.00	p < 0.005	11.72	p < 0.005	4.00	0.025 < p < 0.05
1960-67	0.08	0.75 < p < 0.90	33.08	p < 0.005	40.88	p < 0.005	11.36	p < 0.005

TABLE 6. *Distribution of various maturity stages of oil sardine*

Year	1960—61			1961—62			1962—63		
Months	R	D	P	R	D	P	R	D	P
July	I	I	100.0	..	..	..	II-V, VIIa	V	77.0
August	Indet. I, II, V & VIIa	I	61.9	IV, V, VII	V	91.0	III-V, VIIa	V	52.8
September	I-V & VII	I	75.3	Indet. IV, V	Indeterminates	82.2	Indet., I, IV, V	Indet.	89.6
October	Indet. I-V	I	89.6	Indet., Immature (Data on immature fish inadequate)			Indet., Immature (Data on immature fish inadequate).		
November	Indet. I-III	I	51.3	I, II	I	99.0	I	I	100.0
December	Indet. I-III	I	69.3	I, II, IV, VII	II	68.9	I-II	I	94.6
January	I—II	I	73.5	I-II	I	58.9	I-II	I	69.0
February	..	..	..	I-II	I	51.9	I-III	II	44.7
March	I-III	I-II	43.9 & 43.9	II	II	100.0	II-III	II	96.7
April	I-IV	II	48.9	II-III	II	87.5	II-III	II	60.0
May	..	..	..	..	..	..	..	..	..
June	..	..	..	..	..	..	..	..	..

R = Range of maturity stage; D = Dominant maturity stage; P = Percentage of dominant stage; Indet. = Indeterminates.

TABLE 6. (Continued)

Years	1966-67		
Months	R	D	P
July	..	..	..
August	Indet. I, III, IV, V, VII, VIIa	Indet.	78.1
September	Indet. I, II, III, VII, VIIa	Indet.	88.7
October	Indet. I-V, VII, VIIa (Data on immature fish inadequate)	VII	35.0
November	I-III, VII	II	48.2
December	I-IV, VII	II	45.0
January	I-III, VII	II	62.3
February	I-III, VII	II	54.3
March	I-III, VII	II	45.5
April	I-IV, VII	III	78.9
May	II-V, VII	III	68.1
June	III-V	IV	62.3

GENERAL OBSERVATIONS

In Australian waters Kesteven (1942) observed the predominance of males in *Mugil dobula* which he attributed to differential fishing. This may not be so in the case of oil sardine since no differential fishing has been observed.

The χ^2 tests have shown that the same sex ratio is being maintained throughout the fishing season. The apparent variations in the monthly sex ratios may be due to sampling variations. Furthermore, the study has also revealed that there is no shoaling or concentration of one sex in any month of the year, especially during the spawning season.

It is known that the oil sardine fishery is largely supported by the one-year class and in certain years by the two-year class. The statistical tests for the various year-classes showed that in one-year-old fishes females generally outnumbered the males but in two-year-old fishes, both the sexes were in the same proportion.

It has been pointed out earlier (Chidambaram, 1950; Nair, 1952) that during the south-west monsoon the salinity and temperature of the inshore waters fall, and these, to a large extent, act as favourable factors for the entry of the spawners in the

coastal waters. The present observations have also shown that from June to September (south-west monsoon) the spawners dominate the fishery. It is, therefore, apparent that possibly active spawning, as deduced by earlier workers, takes place during this period.

Another feature worth mentioning is the occurrence of oil sardine in various degrees of spent stage from July to September and in some years this stage extends up to October. This clearly indicates that the oil sardine has a long spawning season (Prabhu and Dhulkhed, 1967) and that the eggs are released in batches (Dulkhed, 1964). Sekharan and Dhulkhed (1963) have reported from Mangalore, the recruitment of different broods in the fishery during August-October, and this lends further support to the deduction that the spawning season is long.

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