FECUNDITY FLUCTUATIONS IN THE OIL-SARDINE, *SARDINELLA LONGICEPS* VAL.

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ABSTRACT

The functional relationship between fecundity and length in the oil-sardine is curvilinear and that between fecundity and weight is rectilinear. Comparing the relative merits of the two relationships, the study has revealed that it cannot be held that the fecundity,-weight relationship is better as a rule. On the other hand, a comparison made of expected fecundity and weight ad'usted to a common length shows that, in general, the heavier fish of identical length are more fecund. For a given length or weight the fecundity variations are considerable.

Although the 2-year old fish are more fecund as compared to the 1-year olds, the former have less ova per gram body weight; the fecundity of the 1-year olds is a fairer guide for estimating the ova potential for the spawning season because of their major contribution in the spawning population. It is estimated that about 10% of ova are lost due to follicular breakdown. The fluctuations in the fishery for juveniles are found to be directly associated with the fluctuations in fecundity. An average of 27,000 to 57, 000 ova may be produced per individual fish according to increasing length, with an overall average of 37,000 to 38,000 ova per fish. It is estimated that, on the basis of weight, 750 million ova are produced per tonne of adult female population.

INTRODUCTION

The literature on oil-sardine investigations contains considerable information on various biological aspects like growth, feeding, maturity, spawning habits and fishery. But except for the reports of Devanesan (1942), Nair (1959) and Balan (1971) very little information is available on the fecundity of this most important commercial fish. The present paper deals with the observations of the author on the fecundity of oil-sardine made at Calicut during the years 1960-65.

MATERIAL AND METHODS

Fecundity estimations were made on 114 normal ovaries and 30 others that had experienced atresia. The ovaries were preserved in modified Gilson's fluid (Simpson, 1951) for about a month. This time-lapse enabled the breakdown of ovarian tissues considerably so that after a few vigorous shakes with water all the ova were completely liberated from the ovigerous lamellae. After the ova had settled down, the supernatant liquid was decanted and the procedure was repeated

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3-4 times. The washed eggs were transferred on a blotting paper and air-dried for 30 minutes with frequent change of blotting paper. The entire mass of ova was weighed to the nearest 0.0002 g. From this, two sub-samples were taken and each was weighed in an identical manner and the number of ova were counted under a binocular microscope fitted with an eye-piece micrometer.

The advantage of this method is that not only are the ova completely liberated, but the immature oocytes are also washed away during repeated decantings, so that only the yolked ova are left behind. There may be some additional shrinkage of mature ova in Gilson's fluid as compared to formalin as reported by Joseph (1963a).

Since it is known that in the oil-sardine two batches of ova develop in the ovaries towards maturation (Antony Raja, 1967), the number in both the batches was counted separately. Ova measuring 0.45 mm and above were taken to represent the more advanced modal group and those less than 0.45 mm, the secondary group. As it has been shown already that the ova belonging to the latter group get resorbed after the first batch has been released (Antony Raja, 1967) the data on them were used only to calculate their percentage occurrence in relation to the larger-sized group. Thus, the fecundity in this study is the number of ova in the principal mode multiplied by the weight of the entire mass of ova and divided by the weight of the sample. Two such estimates were made based on two sub-samples and the average was taken to represent the fecundity of that fish.

RESULTS AND DISCUSSION

Relation between fecundity and length

The scatter diagram of fecundity-length data is presented in Fig. 1. The relationships expressed for different years, using the formula $Y = aX^b$, are shown in Fig. 2 and are based on the following equations:

For   1960, $\log Y = 3.1536 \log X - 5.5221$
1961, $\log Y = 3.2083 \log X - 5.5748$
1962, $\log Y = 1.7950 \log X - 2.3660$
1963, $\log Y = 1.7988 \log X - 2.5152$
1964, $\log Y = 4.5077 \log X - 8.4855$
1965, $\log Y = 3.0453 \log X - 5.2073$

where Y represents fecundity in thousands of ova and X, fish length in mm.

In order to test whether there are any significant differences between the years in the relationship, analysis of covariance (Snedecor, 1955) was done on the regression statistics. The tabulated results (Table 1) indicate that while there is no significant difference in the slopes of the regression, the differences between the adjusted means are highly significant at 1% level. How much of difference is seen between the years is shown in Fig. 3 wherein the mean fecundity values, $\hat{\mu}y$, adjusted for 169.2 mm, the grand mean length, are shown with their 95% fiducial limits. It
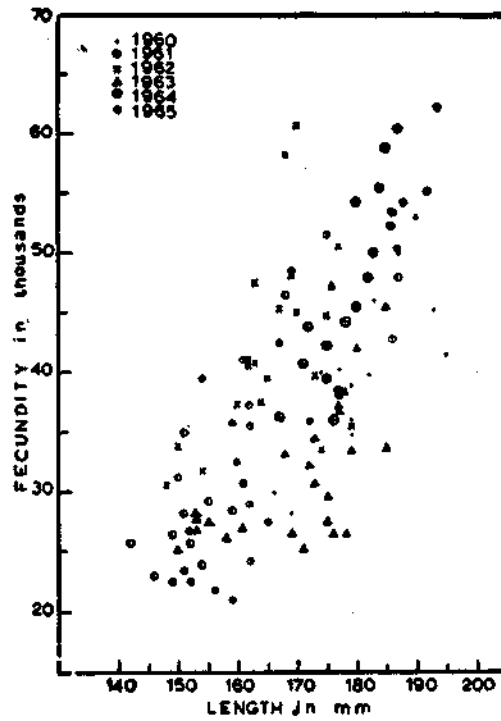
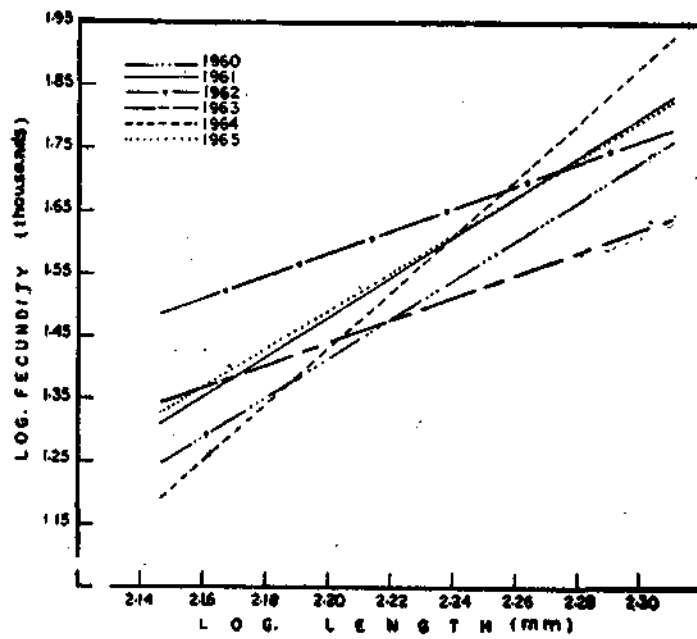FIG. 1 Scatter diagram of fecundity on length of oil-sardine.

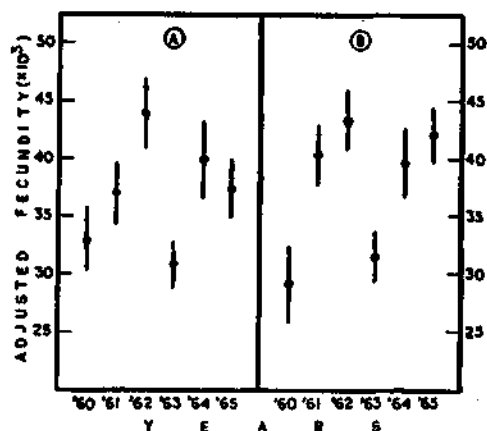FIG. 2 Fecundity-length regression, log Y = log a + b log X.

FIG. 3 Adjusted mean fecundity with 95% confidence limits for (A) grand mean length of 169.2 mm and (B) grand mean weight of 45.9 g.

is seen that while the fecundity was highest in 1962, the other extreme was noticed in 1963 with intermediate conditions prevailing in the other years.

TABLE 1. *Analysis of covariance of fecundity-length data between the years 1960-1965 using log - log relationship*

Source of variation	Sum of squares	degrees of freedom	Mean square	F
Total	0.78332243	112		
Pooled	0.48647944	107	0.00454654	
Within	0.44593408	102	0.00437190	
Difference between regression coeff.	0.04054536	5	0.00810907	1.85
Difference between adjusted means	0.29684299	5	0.05936860	13.06**

TABLE 2. *'t' test for significant departures in b values from 3 in the fecundity-length regression, $Y = aX^b$, for the years 1960-1965.*

Year	b	s_b	d.f.	t	$t_{0.05}$
1960	3.1536	0.6460	11	0.238	2.201
1961	3.2083	1.0701	17	0.195	2.110
1962	1.7950	0.7399	18	1.629	2.101
1963	1.7988	0.4774	23	2.516	2.069
1964	4.5077	0.7894	13	1.910	2.160
1965	3.0453	0.2107	20	0.215	2.086

b = regression coefficient; s_b = standard error of b.

To see whether the *b* values obtained for different years significantly differ from 3, *t* test was performed (Snedecor, 1955) and it is seen from Table 2 that except for 1963, all the other *b* values do not deviate significantly.

Relation between fecundity and weight

The scatter diagram of fecundity-weight data for the different years is shown in Fig. 4. The relationship between these two variants has almost been considered to be a linear function of the form $Y = a + bX$. In the present study also the same expression has been employed and is shown in Fig. 5 based on the following equations obtained:

$$\text{For } 1960, Y = 0.696X - 0.48$$
$$1961, Y = 0.717X + 6.70$$
$$1962, Y = 0.820X + 5.63$$
$$1963, Y = 0.592X + 4.49$$
$$1964, Y = 1.209X - 18.21$$
$$1965, Y = 1.053X - 5.07$$

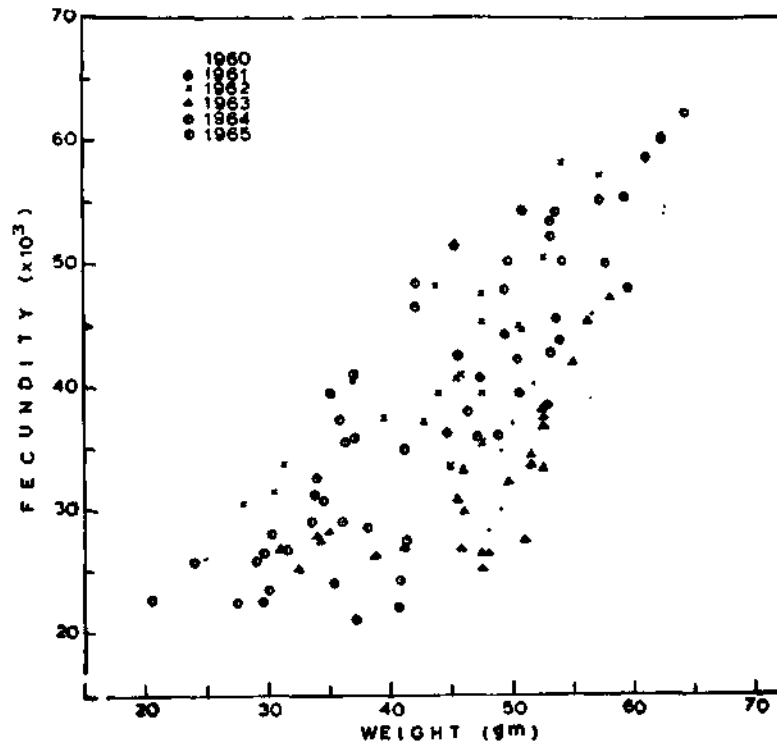where Y represents fecundity in thousands of ova and X, fish weight in grams.

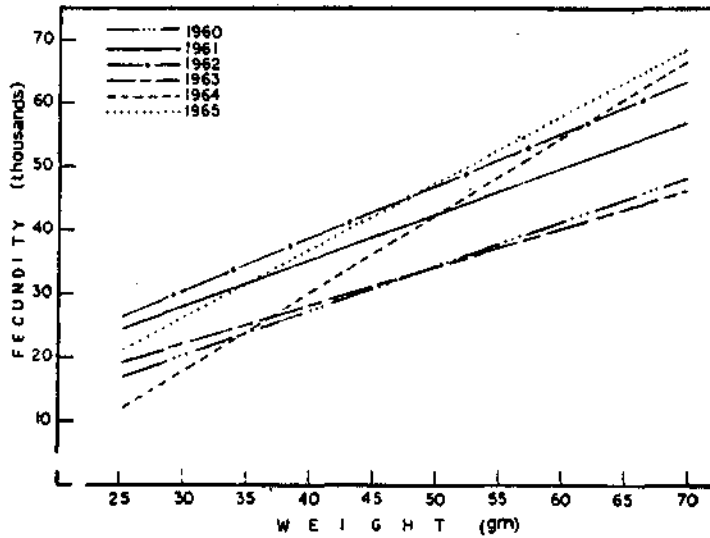FIG. 4 Scatter diagram of fecundity on weight.

FIG. 5 Fecundity-weight regression, $Y = a + bX$

Table 3 presents a comparative picture of a, b, percentage total variation due to regression, standard error of estimate, correlation coefficient and F values to test the linearity for the different years. It is seen that the percentage total variation due to regression shows very wide fluctuations between 20.6 in 1961 and 93.9 in 1965. However, except for 1961, it is found to be more than 50% in all the other years. The correlation coefficient is also rather high in all the years except 1961.

TABLE 3. *Comparison of fecundity-weight relationship for the years 1960-1965*

Year	N	b	a	% S$\hat{y}^2$	s$_y$ (1000s)	r	F
1960	13	0.696	—0.48	66.2	4.40	0.814	21.52**
1961	19	0.717	6.70	20.6	8.38	0.453	44.02**
1962	20	0.820	5.63	63.2	5.02	0.795	30.88**
1963	25	0.592	4.49	54.1	4.40	0.735	27.06**
1964	15	1.209	—18.21	69.4	4.58	0.833	29.45**
1965	22	0.053	—5.07	93.9	3.39	0.940	30.71**

S$\hat{y}^2$=percentage total variation due to regression; sy=Standard error of estimate.

An analysis of covariance was executed on the regression data of fecundity-weight to find the differences, if any, between the slopes and adjusted means. The results are presented in Table 4 from which it may be noticed that as in the case of

fecundity-length relationship, there are no significant differences among the slopes but the adjusted means present highly significant differences. Fig.3, wherein the values of fecundity adjusted for a grand mean weight of 45.9 g are shown, indicates that 1960 and 1963 seasons had lower values as compared to the other years among which differences did not appear to be marked.

TABLE 4. *Analysis of covariance, linear regression of fecundity on weight data between the years 1960-1965*

Source of variation	Sum of squares	degrees of freedom	Mean square	F
Total	5835.4360	112		
Pooled	3125.2789	107	29.2082	
Within	2818.3486	102	27.6309	
Difference between regression coeff.	306.9303	5	61.3861	2.22
Difference between adjusted means	2710.1571	5	542.0314	18.56**

Relationship between fecundity and age

Earlier studies have shown that every spawning season witnesses the entry of two successive generations of spawners, virgin and recovering, representing age 1 and 2 years respectively (Antony Raja, 1967 & 1972). The ranges and averages of the observed fecundity values for the different years are given in Table 5. It may be seen that generally in all the years the older fish gave higher values of fecundity, although the ranges showed some overlapping in certain years.

TABLE 5. *Fecundity (in thousands) - age data*

Year	1 - year old		2 - year old	
	Range	Average	Range	Average
1960	28.3 - 40.3	35.6	41.6 - 53.1	47.2
1961	21.0 - 46.5	31.9	35.9 - 51.5	45.4
1962	30.5 - 47.6	42.2	33.5 - 60.9	45.6
1963	25.3 - 33.2	27.8	26.4 - 47.6	35.0
1964	35.9 - 48.1	39.6	44.3 - 60.4	52.1
1965	22.5 - 35.1	27.1	48.1 - 62.3	53.2
Combined	21.0 - 48.1	32.3	26.4 - 62.3	45.0

From the scatter diagrams of fecundity-length and fecundity-weight relationships it is apparent that for a given length or wieght, the fecundity varies considerably even within the same season. Workers studying the fecundity of different fishes have

also noticed a similar high degree of variation but have concluded that these variations are of biological origin and not due to sampling error (Simpson, 1951; MacGregor, 1957; Joseph, 1963 a and b; Raju, 1964). Similarly, when the percentages of total variations due to regression for different years are compared, it may be noticed that for fecundity-length relationship it is as low as 24.9 for 1962 and as high as .391 for 1965 and for fecundity-weight relationship, the extreme limits are 20.6 and 93.9 for 1961 and 1965 respectively. Except for the fact that the low percentage is a reflection of a poorer correlation for those particular years between the two variables studied, it is not possible to attribute these large-scale differences specifically to any other feature and it can be further added that these may also be of biological origin and not due to any differences in the sampling procedure.

MacGregor (1957), comparing the partial correlation coefficients of fecundity-length, fecundity-weight and length-weight relationships, indicated that the fecundity was better correlated with weight and the correlation with length was merely a reflection of the very good correlation between length and weight. In Table 6 is presented a comparative picture of the values of r and r (partial) for the three relationships. The relation between weight and length was worked out on the allometric formula, $W = aL_n$, as was done in an earlier study (Antony Raja, 1971b). A perusal of these values shows that although there is a very good correlation between weight and length in all the years, the same cannot be said as a rule for either the fecundity-length or fecundity-weight relelation. It is seen that while for three years, 1960, 1961 and 1965, the fecundity-length relationship appears to be better, for the other three years, 1962, 1963 and 1964, the fecundity-weight relation should be preferred.

TABLE 6. *Comparison of fecundity - length and fecundity - weight correlations*

Year	item	Fecundity-length	Fecundity-weight	Length-weight
1960	r	0.829	0.814	0.885
	r (partial)	0.402	0.309	0.647
1961	r	0.586	0.453	0.885
	r (partial)	0.446	—0.174	0.780
1962	r	0.500	0.795	0.835
	r (partial)	-0.491	0.792	0.833
1963	r	0.615	0.735	0.950
	r (partial)	-0.393	0.612	0.931
1964	r	0.857	0.995	0.870
	r (partial)	-0.176	0.997	0.336
1965	r	0.955	0.940	0.949
	r (partial)	0.585	0.360	0.507

MacGregor (1957) and Raju (1964) further showed that by using the condition factor, K, as a correction to the fecundity-length relationship of the form, $Y = a + bX$ the above view-point, that fecundity-weight relation is better, can be proved. A similar attempt was also made during the present study to examine whether the relationship is improved by the use of the condition factor. For each season the regression, $d = a' + b'k$, where K is the condition factor, d, the deviation in fecundity (observed fecundity *minus* calculated fecundity) of each of the fecundity-length pair of each season was worked out as also the standard error of estimate and the correlation coefficient. When this regression equation is added to the fecundity-length regression, $Y = a + bX$, as a correction for differences in K values among the fish, the resultant equation is $Y = a + a' + bX + b'K$. The correlation coefficient $r_{yx \cdot k}$ was compared with r_{yx} of the original fecundity-length relationship to see whether there is any improvement in the correlation coefficient. The tabulated values of comparison (Table 7) shows that as a result of correction, there is only a slight improvement in the years 1960, 1963, 1964 and 1965 while in 1961, r is actually

TABLE 7. *Comparison of fecundity-length relationship* $(Y = a + bX)$ *with a correction involving the condition factor,* K

Year	item	Fecundity-length $Y = a+bX$	Correction $d = a' + b'K$	Combined $Y = a+a'+bX+b'K$
1960	s_y	4. 52	4. 25	..
	r	0.802	0.340	0.829
1961	s_y	7. 60	7. 49	..
	r	0.588	—0.545	0.532
1962	s_y	7. 36	4. 86	..
	r	0.454	0.711	0.603
1963	s_y	5. 17	5. 19	..
	r	0.606	0.095	0.621
1964	s_y	4. 35	4. 14	..
	r	0.851	—0.349	0.869
1965	s_y	3. 58	3. 17	..
	r	0.967	0.420	0.974

reduced. Only for the year 1962, can it be said that there is a distinct improvement in r as well as a distinct decrease in the standard error of estimate; otherwise there is no marked difference in the latter for the other seasons.

In Table 8 are listed the means of observed length, weight and fecundity and the adjusted values of weight and fecundity for 169.2 mm, the grand mean length.

It is noticed that $\hat{W}$ was maximum for 1960 followed by 1962, 1964, 1963, 1961 and 1965 and $\hat{F}$ was greater in 1964 followed by 1962, 1960, 1965, 1961 and 1963. Although a uniform proportionate increase or decrease could not be noticed, the indicated general pattern is that fish of better weight were more fecund as in the years 1960, 1962 and 1964 and those lighter were less fecund as in 1961 and 1965. The only exception is seen in 1963 when although the adjusted weight was nearer to that of 1962 and 1964, the fecundity was low, the reason for which is discussed later.

In a similar way, it may be also worthwhile to see whether among two fish of the same weight, the shorter one is more fecund. A perusal of Table 8 will show

TABLE 8.   *Comparison of mean and adjusted values of length (L) in mm,
weight (W) in g and fecundity (F) in thousands of ova*

Year	Mean			Adjusted					
	L	W	F	$\overline{L}$	$\hat{W}$	$\hat{F}$	$\overline{W}$	$\hat{L}$	$\hat{F}$
1960	181.0	58.3	40.1	169.2	48.2	39.5	45.9	168.5	29.3
1961	164.6	40.1	35.5	169.2	43.0	34.3	45.9	172.0	40.5
1962	165.7	44.4	42.0	169.2	46.5	41.3	45.9	168.0	43.4
1963	170.0	46.2	31.8	169.2	45.2	31.3	45.9	170.1	31.6
1964	178.1	53.3	46.2	169.2	46.4	45.6	45.9	170.3	39.8
1965	165.0	39.6	36.6	169.2	41.3	34.5	45.9	174.1	42.1

that for a grand mean weight of 45.9 g, no such correlation is obtained. While for shorter fish, high and low fecundity rates were seen in 1962 and 1960 respectively, in 1965 both $\hat{F}$ and $\hat{L}$ were high. MacGregor (1957) also hesitated to conclude that shorter fish among the two of the same weight is more fecund because of low value of *r* and the small improvement caused by the K correction to the fecundity-weight relationship. Since in the fecundity-length relationship the percentage of variation due to regression is very low for 3 out of 6 years whereas such a situation is met with only for one year in the case of length-weight relationship, and in view of the fact that though small, some improvements are effected by applying the condition factor as a correction over the fecundity-length relation, and also by the general feature that heavier fish appear to be more fecund when adjusted to a common length, it may be proper to say, under reasonable limits, that the fecundity of the oil-sardine is slightly more closely associated with weight than with length.

There is some difference of opinion among the workers on the fecundity-age relationship. While MacGregor (1957) and Simpson (1951) have found poorer correlation as compared to weight or length, Lehman (1953) has obtained a better one. Peterson (1961), although he could not correctly describe the fecundity-age relationship in view of difficulty in determining the age, concluded that the majority

contribution was made by the younger spawning population of one year olds. In the present study it is seen that the recovering spawners, representing the 2-year olds, were distinctly more fecund than the virgin spawners. But in the oil-sardine fishery it is well-known that the virgin spawners represented by the 1-year olds make the major contribution to the spawning stock (Antony Raja, 1967). Comparing the fecundity of one year olds (*vide* Table 5) it is seen that the mean fecundity was highest in 1962 followed by 1964, 1960, 1961, 1963 and 1965 in that order and hence it should be expected that the stock belonging to these years should be comparatively more fecund in the subsequent years in the same order, namely, in 1963, 1965, 1961, 1962 and 1964. On the other hand, the observed means show the order to be 1965, 1964 1962, 1961 and 1963. Hence, it appears that some explanation is due for the recovering spawners of 1963 which, instead of recording a high fecundity, showed the poorest, and for the recovering spawners of 1964 which, instead of maintaining the comparatively low fecundity of the previous year, actually showed a phenomenal increase. It has already been reported that in 1963 the ovaries of both virgin spawners and recovering spawners had a very large percentage of immature and maturing oocytes of the secondary mode as compared to the other years (Antony Raja, 1967) and hence the amount of mature ova belonging to the advanced mode which has been taken to represent fecundity was considerably less. Since the fecundity of both the spawning groups, younger and older, has been affcted in the same year, it is presumed that it may be due to the influence of some unfavourable environmental conditions during 1963 season. One of the reasons may be poorer monsoon conditions and lesser rainfall during that year (Antony Raja, 1972). Since in 1964 the recovering spawners had a very high fecundity —a group which was characterised by low fecundity in the previous year—it is reasonable to conclude that it was the unfavourable environment that was responsible for the development of lesser number of ova in the previous year but, with the conditions becoming favourable in 1964, the process of maturaton might have proceeded in the normal way without affecting the fecundity.

It has been shown that incidence of atresia in advanced ovaries in the oil-sardine might affect the number of mature ova earmarked for release (Antony Raja, 1967, 1971a and 1972). To see how much of ova are affeeted by the follicular break-down, the fecundity of those ovaries that had experienced atresia was estimated in the same way as for the other normal ovaries. The results are presented in Table 9. It is seen that the percentage loss varied between 1.4 and 11.2 on the basis of length and between 6.8 and 12.9 on the basis of weight. The maximum loss was seen in 1963 and the minimum in 1964. The loss on the basis of weight appears, in general, greater than that related to length. Since the weight-basis has got more value in respect of evaluating population sizes, it can be said that roughly 10% of ova are likely to be lost due to atresia in the ovaries.

As it has been shown that the commercial fishery is mainly supported by 0-year class resulting from the spawning of the same year (Bensam, 1968; Antony

TABLE 9. *Percentage loss due to artesia during the year* 1960-1965.

Year	No. fish	Mean length (mm)	Mean weight (g.)	Mean fecundity (1000s)	Expected fecundity (1000s) in relation to		Percentage loss on the basis of	
					length	weight	length	weight
1960	4	177	54.6	35.0	36.9	38.5	5.3	9.1
1961	5	169	43.3	34.2	37.4	37.8	8.6	9.5
1962	4	169	44.5	38.7	43.0	42.1	10.0	8.1
1963	6	167	44.7	27.0	30.4	31.0	11.2	12.9
1964	5	176	52.9	42.7	43.3	45.8	1.4	6.8
1965	6	170	45.3	34.9	38.5	42.6	9.4	18.1
Average		171	47.2	35.0	37.6	38.9	6.9	10.0

Raja, 1972), it would be interesting to see whether the fecundity fluctuations of the different years have got any relevancy to the fluctuations in the fishery. It may be noted from the landing data (Prabhu, 1967) that after a bumper crop in 1960, the fishery was showing a steady but slow decline in the following years and culminated in a failure in 1963 with a record revival again in 1964. The fecundity records during the present study also shows the lowest values for 1963 both for virgin and recovering spawners and this was attributed to some unfavourable ecological conditions inhibiting the normal maturation process. Since it has also been shown in this study that the loss due to atresia had also been greater for this particular year and that the percentage incidence of fish exhibiting the follicular breakdown was also the highest for this year during the 1960—1963 period (Antony Raja, 1967), it is reasonable to relate the failure of the fishery in 1963 to the unsatisfactory maturation and spawning process exhibited by the ovaries. Among the other three preceding years, the 1962-fish carried the highest fecundity count followed by 1961 and 1960, whereas the landings data showed the reverse order with more landings in 1960 and declining figures for 1961 and 1962. The reason for the high value of fecundity in 1962 was due to an unusual feature of higher-than-normal percentages of the yolked ova belonging to the advanced mode as compared to those of the secondary mode (*vide infra*). In addition to this it was observed in this study that the percentage loss of ova due to atresia was on the increase from 1960 to 1962 and it was shown that the percentage incidence was also on the increase similarly (Antony Raja, 1967). Hence it is possible that the very high values of fecundity in 1962 were offset by increased loss due to follicular breakdown and the cumulative effect would have been a reduction in the total number of ova spawned by the population. Similarly, a fairly high fecundity rate in 1964 in both the virgin and recovering spawners and low incidence of atresia would have contributed to a very successful spawning and with the landings data for 1964 showing the heaviest on record, it is presumed that the

survival rate also would have been exceptionally high. It has been shown in an earlier paper that if the fishery for 1965 proved to be a success, it was not due to the usual contribution of the 0-year class but mostly due to the 1-year olds which supported the fishery as spent fish (Antony Raja, 1972). From Table 5 it may be seen that the fecundity was the lowest for the virgin spawners of 1965 and the percentage loss of ova due to atresia was fairly heavy. The percentage incidence of atresia also was indeed very high, in fact, higher than 1963 season among the virgin spawners. With the available knowledge it is believed that the spawning might have been rather poor in 1965 for the major part, as contributed by the virgin spawners. Since the recovering spawners did not appear to have suffered in fecundity in 1965 (unlike in 1963), it is possible that the contribution of the recovering spawners was mainly responsible for whatever spawning success was actually registered in that season.

TABLE 10. *Calculated values of weight (g) and fecundity (thousands) of fish of different lengths (mm)*

Length	$\hat{W}$	$\hat{F}$		No. of ova per gram body weight
		lengthbasis	weight basis	
150	31.3	27.1	28.0	894
160	37.8	31.9	32.4	857
170	45.3	37.1	37.6	830
180	53.6	42.8	43.3	808
190	63.0	49.0	49.7	789
200	73.3	57'0	56.8	775

In Table 10 are given the averages of the calculated values of fecundity for each 10 mm interval and corresponding expected weight. It is seen that while about 27,000 ova are produced for a fish of 150 mm length, every additional 10 mm length increases the fecundity by 5 or 6 thousands of ova. It is also seen that the differences in expected fecundity between the values based on length and weight are not great, ranging between 200 and 900 ova only. Since the grand mean of observed length and weight are 169.2 mm and 45.9 g respectively, it can be roughly stated that an average of about 37,000 to 38,000 ova are produced per individual fish. Considering the fecundity in relation to unit weight of fish, it is seen that there is an inverse relationship between the number of ova and increase in weight. Thus, although the older fish may be more fecund (*vide supra*), it is the younger fish that produce more ova per gram weight of the body. On an average it may be held that about 830 ova are produced per gram weight. Since it has already been remarked that about 10% of these are likely to be lost due to atresia, it is probably safer to presume that about 750 ova may be obtained per gram weight of fish, which means 750 million ova are likely to be released for every tonne of adult female population.

Earlier workers on the fecundity of oil-sardine have indicated a high figure of 70,000 to 80,000 ova per individual fish (Devanesan, 1942; Nair, 1959). It is lilkely that the above workers have included in their count all the maturing yolked ova, since Nair (1959) presumed that the secondary mode of maturing ova is also shed along with the more advanced one. It is now known that the less advanced modal group of ova actually gets resorbed after the release of the more advanced group (Antony Rja, 1967). Table 11 shows the percentage of ova in the two modal groups

TABLE 11. *Percentage of ova in the two modal groups in different years*

Year	Range		Average ratio
	Principal mode	Secondary mode	
1960	71.1-78.7	21.3-28.9	74.5:25.5
1961	66.5-74.3	25.7-34.5	70.2:29.8
1962	76.3-96.4	3.6-23.7	88.2:11.8
1963	64.3-88'4	11.6-35.7	77.0:23.0
1964	66.0-72.2	27.8-34.0	69.3:30.7
1965	67.1-88.8	11.2-32.9	77.3:22.7

in the different years. Except in 1962, when the secondary mode represented a considerably lower percentage as compared to the other years, in general, the percentage ratio of the principal and secondary mode is of the order 70 - 75: 25 - 30. Based on this, while the average calculated total number of ova ranges from 40,000 to 80,000 for increasing sizes of fish, the actual observed range was between 30,000 and 90,000. Hence, it appears reasonable to conclude that the high estimation of fecundity by the earlier workers resulted from the count of all yolked ova as potential eggs for release. Recently Balan (1971) has obtained an average fecundity of 48,000 ova for the oil-sardine. It is not known whether this count also includes the secondary batch of smaller yolked ova.

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REFERENCES

ANTONY RAJA, B.T. 1967. Some aspects of spawning biology of Indian oil-sardine, *Sardinella longiceps* Valenciennes. *Indian J. Fish.*, 11A (1), 45-120 (1964)

ANTONY RAJA, B.T. 1971a On the maturity stages of Indian oil-sardine, *Sardinella longiceps* Val. with notes on incidence of atretic follicles in advanced ovaries. *Indian J. Fish.*, 13: 27-47 (1966).

ANTONY RAJA, B.T. 1971b. Length-weight relationship in the oil-sardine, *Sardinella longiceps* Val. *Indian J. Fish.*, 14: 159-170 (1967)

ANTONY RAJA, B.T. 1972. Estimation of age and growth of the Indian oil- sardine, *Sardinella longiceps* Val. *Indian J. Fish.*, 17: 26-42 (1970).

BALAN, V. 1971. The fecundity and sex composition of *Sardinella longiceps* Val. along the Cochin coast. *Indian J. Fish.*, 12A (2): 473-491.

BENSAM, P. 1968. Growth-variations in the Indian oil-sardine, *Sardinella longiceps* Valenciennes. *Indian J. Fish.*, 11A (2), 699-708. 1964.

DEVANESAN, D.W. 1942. A brief investigation into the causes of the fluctuations of the oil-sardine of Malabar, *Sardinella longiceps* Cuv. & Val., determination of its age and an account of the discovery of its eggs and spawning ground. *Madras Fish. Bull.*, 28: 1-38.

JOSEPH, J. 1963a. Fecundity of yellowfin tuna (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) from the Eastern Pacific Ocean. *Inter-Amer.Trop. TunaComm. Bull.*, 7 (4): 257-277..

JOSEPH, J. 1963b. Contributions to the biology of the engraulid *Anchoa Naso* (Gilbert & Pierson 1898) from Ecuadorian water. *Inter-Amer. Trop. Tuna Comm. Bull* 8 (1): 1-20.

LEHMAN, B.A. 1953. Fecundity of Hudson River Shad. *U. S. Fish. Wild. Serv. Res. Rept.*, 33:8 pp.

MAC GREGOR, J.S. 1957. Fecundity of the Pacific sardine (*Sardinops caerulea*). *U.S. Fish Wild. Serv. Fish. Bull.*, 121, 57: 427-449.

NAIR, R.V. 1959. Notes on the spawning habits and early life history of the oil sardine, *Sardinella longiceps* Cuv. & Val. *Indian J. Fish.*, 6 (2): 342-359.

PETERSON, C.L. 1961. Fecundity of the anchoveta (*Cetengraulia mysticetus*) in the Gulf of Panama. *Inter-Amer. Trop. Tuna Comm. Bull.*, 6 (2): 55-62.

PRABHU, M.S. 1967. The oil sardine. *Souvenir, 20th Anniversary.* 41-43. Cent. Mar. Fish Res. Inst., Mandapam Camp.

RAJU, G. 1964. Fecundity of the oceanic skipjack *Katsuwonus pelamis* (Linnaeus) of Minicoy. *Proc. Symposium on Scombroid Fishes*, Part II: 725-732. Marine Biological Association of India, Mandapam Camp.

SIMPSON, A.C. 1951. The fecundity of the plaice. *Fish. Invest. Lond.*, Ser. 2, 17 (5): 27 pp.

SNEDECOR, G.W. 1955. *Statistical methods.* Fourth Edition, The Iowa State College Press Ames, Iowa, 485 pp.