THE FECUNDITY AND SEX COMPOSITION OF SARDINELLA LONGICEPS VAL. ALONG THE COCHIN COAST

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A clear knowledge of the fecundity, sex composition and breeding of fishes is an essential prerequisite in any programme of fishery research and management policies. In *Sardinella longiceps*, which is economically very important, attempts to study these were hitherto made only in the Calicut area (Hornell, 1910; Hornell and Jayudu, 1923; Sundara Raj, 1934-40; Devenesan, 1943; Devanesan and Chidambaram, 1948; Chidambaram, 1950; Nair and Chidambaram, 1951 and Nair, 1952 and 1960) and our present knowledge on these aspects of its biology is rather meagre. These authors stated that the fish was highly fecund and the fecundity ranged from 70,000 to 100,000 eggs during the years of their observation. In view of those variations of fecundity values and sex composition of the fish, a detailed investigation pertaining to them was taken up at Cochin. Observations of Clark (1934), Hickling (1940), Lehman (1953), Davies (1956), Mac Gregor (1957), Pillay (1958), Kandler and Dutt (1958), Baxter (1959), Schuster (1960), Larraneta (1960), Ben Tuvia (1960), Kwan-Ming (1960), Ahlstrom (1960), Ronquillo (1960), Blackburn (1960), De Jager (1960), Pillay and Rosa (1963), Beverton (1963) and Anokhina (1963) on fecundity, sex, maturity and related aspects of various sardines and related clupeids are of special interest in this connection. However, the investigations on those aspects of other species of fishes by Hickling and Rutenberg (1936), Jones (1946), Bagenal (1957), Wise (1961) and Thomson (1962) are also worthy of mention here.

Material and Methods

The ripe sardine in stage V of maturation only, *i.e.*, just before the commencement of spawning activity, were selected from Cochin (Manassery) fish landing centre for the estimates of fecundity. The weight of each individual sardine correct to 0.5 gm. and the length to 0.1 cm. were recorded. The ovaries were collected from fresh fish and preserved in 5.0% formalin. Moisture was thoroughly blotted from ovaries before recording their total-weight. To obviate any possibility of error due to the uneven distribution of the eggs the following procedure was adopted: from the posterior, middle and anterior regions of both the lobes of the ovary, portions weighing 200 mg. were taken. The eggs were separated individually and cleaned, and the number of ripe eggs contained in this sample of

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200 mg. was counted; and the total number of ripe eggs in the ovary was estimated by multiplying the number of ripe eggs in the sample by the ratio of the ovary weight to the sample weight. The lengths of the ovaries were also noted down. The samples for the study of sex composition were taken three days in a week from boat-seine catches. As soon as samples were brought to the laboratory, the individual fishes were cut open and sexes recorded. The sexes of the immature fish were determined by microscopic examination of gonads. The individuals whose sexes could not be distinguished under microscope were classified as "indeterminate". The sexes of fish in stage II of maturation and above were easily identifiable by the naked eye. A total of 15,477 fishes was sexed during the course of this investigation, from 1959 to 1965.

FECUNDITY

Frequency distribution of the egg diameters of the oil sardine in stage V of maturation has revealed that there is only one group of maturing eggs, well separated from the immature egg stock. As the frequency curves of those maturing groups of eggs are unimodal with a narrow range of distribution, it can be inferred that the shedding of eggs takes place in one batch within a short time. It is in agreement with the findings of Nair (1953 & 1960) on the oil-sardine and is also in line with those of Hickling and Rutenberg (1936) on pilchard, herring, haddock, hake etc., that "where the spawning period is short and definite, the batch of transparent yolkless small eggs, destined to mature and be spawned, will be withdrawn from the general egg stock in a single group, sharply distinguishable, at least in the later stages of maturation, from the stock of small eggs from which it was derived."

TABLE I. *Fecundity estimates of* S. longiceps *at Cochin.*

Serial No.	Date	Total length of fish (Cm.)	Total weight of fish (gm)	length of ovary (Cm.)	Weight of ovary (gm.)	No. of ripe Ova in sampled portion	Estimated total of eggs
1	2	3	4	5	6	7	8
1	29-5-59	18·2	52·0	5·2	4·150	1,831	38,001
2	29-5-59	18·5	50·5	5·8	5·500	1,544	42,460
3	29-5-59	18·7	55·5	5·9	6·000	1,433	43,000
4	29-5-59	18·9	54·0	5·9	6·000	1,320	39,600
5	29-5-59	19·0	54·5	6·2	6·010	1,334	40,100

TABLE I (*Contd.*)

1	2	3	4	5	6	7	8
6	29-5-59	19·5	55·0	6·1	6·120	1,637	50,105
7	8-6-59	18·5	52·5	6·0	3·900	2,708	52,806
8	23-7-59	19·0	53·5	6·5	6·250	1,866	58,312
9	23-7-59	16·4	42·0	5·0	3·500	2,000	35,000
10	23-7-59	16·9	41·5	5·1	5·100	1,440	36,720
11	17-8-59	16·5	40·0	5·1	5·000	1,814	45,356
12	17-8-59	17·8	47·5	5·2	4,815	2,140	51,520
13	22-6-60	16·2	44·0	5·0	4·115	2,218	45,635
14	22-6-60	16·5	45·5	5·1	5·062	1,792	45,350
15	22-6-60	18·2	56·0	5·5	5·290	1,728	45,705
16	22-6-60	19·0	58·0	6·0	6·100	1,639	49,990
17	22-6-60	19·0	57·0	5·9	6·105	1,606	49,050
18	22-6-60	19·4	58·5	6·0	6·160	1,656	51,000
19	19-7-60	18·5	54·0	5·9	4·005	2,020	40,450
20	12-8-60	17·9	62·0	5·9	4·485	2,100	47,092
21	12-8-60	17·9	55·0	5·5	4·205	1,870	39,317
22	16-6-61	17·6	40·0	5·6	4·135	2,237	45,229
23	16-6-61	17·8	40·5	5·8	4·335	1,970	42,700
24	16-6-61	18·0	40·0	5·6	4·735	1,780	42,142
25	16-6-61	18·3	41·0	5·5	4·485	1,992	44,671
26	16-6-61	18·4	41·5	5·8	4·390	2,020	44,339
27	16-6-61	18·5	44·5	5·8	5·650	1,920	54,240
28	14-7-61	18·2	50·0	5·2	4·050	2,380	48,195
29	29-6-62	17·2	48·0	6·1	5·530	1,670	46,175
30	29-6-62	19·0	53·0	5·2	5·150	2,200	56,650
31	16-7-62	16·5	36·0	6·0	6·090	1,790	54,505
32	15-5-63	18·0	44·5	5·9	6·705	1,599	53,573
33	14-6-63	18·0	49·0	6·6	7·130	1,800	64,170
34	10-7-63	17·0	42·0	5·3	4·225	1,972	41,658

TABLE I (*Concld.*)

1	2	3	4	5	6	7	8
35	10-7-63	17·8	51·0	5·5	4·755	1,884	44,792
36	26-6-64	18·0	53·0	5·6	4·705	1,810	42,580
37	26-6-64	18·5	55·0	6·5	5·975	1,740	51,982
38	8-7-64	19·0	62·0	6·9	6·130	2,090	64,058
39	13-7-64	19·0	70·0	6·3	5·655	2,176	61,526
40	13-7-64	19·9	70·0	6·8	7·605	2,210	84,035
41	13-7-64	19·9	67·5	7·1	6·655	2,030	67,548
42	17-7-64	18·0	53·0	6·0	4·635	1,790	41,483
43	17-7-64	18·0	58·5	6·4	3·980	1,980	39,406
44	22-7-64	17·2	48·5	6·3	4·735	1,790	42,378
45	22-7-64	17·5	55·0	6·3	4·295	1.524	32,728
46	22-7-64	18·0	59·0	6·5	5·235	1,846	48,319
47	22-7-64	18·0	50·5	6·5	6·030	1,804	54,390
48	22-7-64	18·0	50·0	6·5	6·230	1,608	50,089
49	22-7-64	18·4	62·0	7·2	6·500	1,780	57,850
50	27-7-64	18·0	51·5	6·1	6·515	1,578	51,403
51	19-7-65	19·3	56·0	5·8	3·758	2,060	38,703
52	19-7-65	19·5	57·0	5·9	3·810	1,240	47,244
Average			51·7	5·9	5·225	..	48,199

TABLE II. *Yearly averages of fecundity of oil-sardine at Cochin*

Years	Fecundity
1959	44,415
1960	45,954
1961	46,074
1962	52,443
1963	51,048
1964	52,652
1965	42,974

As can be seen from the Table I, the fecundity values for the different individual specimens showed remarkable variations. It may be added that the minimum number of eggs observed (32,728) was in a fish measuring 17.5 cm. in total length; and the maximum number of 84,035, in a fish measuring 19.9 cm. High values of fecundity (within the range) were noticed to some extent in the bigger specimens studied. It is interesting to mention that there were variations in the numbers of ripe ova present in the ovaries of fish having the same length. Nevertheless, as observed by Anokhina (1963) in the case of White Sea Herring, for the oil-sardine also an improvement in the ecological conditions seems to result in improvement of spawning potential of the whole population, this being achieved by a general increase in quantity of eggs (mainly as a result of greater lengths of females, *i.e.*, a higher growth rate, and larger fish coming for prolific spawning).

Based on the estimates of a total of 52 mature ovaries (all in stage V) it is found that, on an average, an ovary contains 48,119 ripe eggs.

(a) *Total length—fecundity relation*

Utilising the 52 specimens of oil-sardine the relation between the total-length of the fish and the fecundity is expressed by the equation: $F = ae^{bL}$, where F

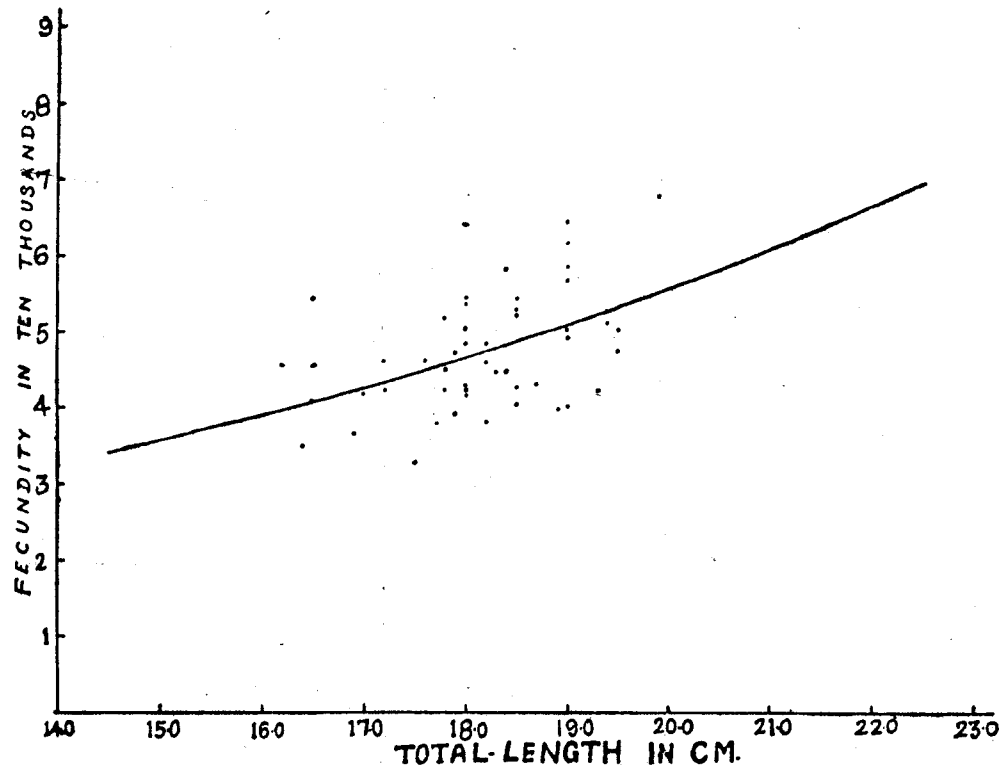

Fig. 1. Relationship between fecundity and total length of *S. longiceps*

represents the fecundity in ten thousands, L the total length of the fish in cm. and a and b the constants and e the base of the Naperian logarithm. The equation is calculated as: $F = 0.9647e^{0.0875 L}$

The equation and the graph indicate that the relationship is that of a parabola (Fig. 1). The exponential relation is found suitable in this case as the values of length in cm. and the corresponding numbers of eggs in ten thousands when plotted in a semi-logarithmic graph paper showed a linear relationship.

(b) *Fish weight—fecundity relation*

The fecundity data thus obtained from the 52 fish have been plotted against weight of fish (Fig. 2). The relation between them is expressed by a linear regression equation of the form: $y = a + bx$, where x and y represent weight of fish in gm. and fecundity in ten thousands respectively, and a and b are constants. The calculated equation is: $F = 2.1263 + 0.0521W$. The test of linearity was applied and the relation was found to be significantly linear.

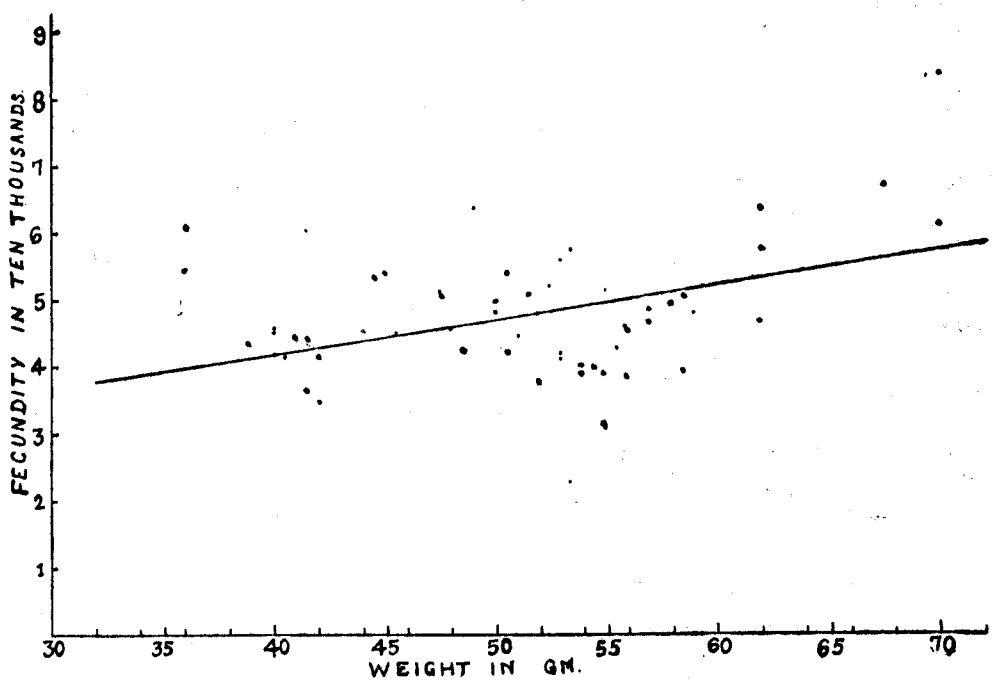

Fig. 2. Relationship between fecundity and weight of *S. longiceps*

Sex Composition

According to Hornell and Nayudu (op. cit.) females dominated in the catches of juveniles till they became mature. Among spawners females were in excess of

males. In spent fish, the males dominated slightly over females, which was ascribed to higher post-spawning mortality among females. Chidambaram (1950) noticed equal proportion of sexes in the fish measuring less than 20 cm. in total length while females predominated in sardine over this size. Nair (1960) observed an almost equal proportion of sexes especially among juveniles and spawners; from the relative scarcity of spent and spent-recovering fish and the negligible numbers of the 4-year old sardine, he inferred that the mortality rate was very high among both sexes after their spawning activity.

Preponderance of females was noticed in the boat-seine catches in all the years in Cochin from 1959 to 1965 except in 1963 when the percentages of females and males were 44.5 and 46.3 respectively (out of the total examined during that year). A possibility for the predominance of females observed in the catches is that during fishing operation with the surface boat-seine *thangu-vala*, a vertical or columnar separation of the sexes takes place resulting in the higher and more passive captures of females (*vide* Table III). It is in line with the view expressed by Larraneta (1960, p. 153) on *Sardina pilchardus*. The abundant occurrence of juveniles accounts for the increase in numbers of the "indeterminate" fish in 1959, 1964 and 1965. At the same time it may be emphasized here that the number of immature fish in stages I and II of maturation was remarkably predominant in the catches during the entire period of this investigation.

Hornell and Nayudu (loc. cit.) further stated that the oil-sardine after attaining maturity leave inshore waters just prior to spawning. The absence of the sardine having gonads in oozing condition (stage VI) in the catches made during the period June to August (the peak season of its spawning) is very significant, which lends support to the findings of Hornell and Nayudu (loc. cit.). From this fact it is reasonable to infer that the ripe sardine migrate temporarily in appreciable numbers to the deeper waters, which are not at all exploited at present, for spawning. Generally, during the monsoon months, mostly the fish in stages IV and V are available in the catches.

In the absence of direct evidences such as those obtained through tagging, it is rather difficult to state anything about the magnitude of mortality among the spent fish or spent-recovering ones. If the mortality rate of the big-sized fish immediately after their breeding was very high, as was presumed by certain previous investigators, their resources would undoubtedly meet with disastrous depletion every year. The seven years' data presented here do not support the view that the post-spawning mortality is very high in all the years. It is probable that appreciable numbers of these big individuals after their spawning act in the offshore areas live for a considerable time there itself before attaining natural senility and death. Nevertheless, the numbers of the spent (VII stage) and spent-recovering sardine re-entering the inshore fishing grounds during the post-monsoon months

TABLE III. *Stages of maturation of oil-sardine in different months*, 1959—'65.

(I.C.E.S. scale followed) (Percentages in brackets)

	Females								Males								Indeterminate	Total examined
	1								2								3	4
1959	I	II	III	IV	V	VII	VIII	Total	I	II	III	IV	V	VII	VIII	Total		
Jan	46	10	..	..	..	..	..	56 (44·8)	11	1	..	..	..	..	..	12 (9·6)	57 (45·6)	125
Feb	50	3	..	..	..	..	..	53 (42·4)	27	..	..	..	..	..	..	27 (21·6)	45 (36·0)	125
Mar	8	7	2	..	..	..	..	17 (34·0)	19	1	..	..	..	..	..	20 (40·0)	13 (26·0)	50
Apr	2	11	5	..	..	..	..	18 (38·3)	18	9	2	..	..	..	..	29 (61·7)	..	47
May	..	10	4	..	..	..	..	14 (56·0)	2	8	..	1	..	..	..	11 (44·0)	..	25
Jun	NO FISHING							—								..	..	..
July	Do.							—								..	..	..
Aug	1	..	..	15	24	2	..	42 (24·0)	..	..	..	13	21	..	..	34 (19·4)	99 (56·6)	175
Sep	11	..	..	..	..	..	..	11 (12·5)	14	..	..	..	..	..	..	14 (16·0)	63 (71·5)	88
Oct	..	..	..	..	..	5	..	5 (11·1)	..	..	..	..	..	1	..	1 (2·2)	39 (86·7)	45
Nov	51	..	..	..	..	..	8	59 (38·8)	2	..	..	..	..	..	9	11 (7·2)	82 (54·0)	152
Dec	74	..	..	..	..	..	..	74 (49·3)	6	..	..	..	..	..	..	6 (4·1)	70 (46·6)	150
Total	243	41	11	15	24	7	8	349 (35·5)	99	19	2	14	21	1	9	165 (16·8)	468 (47·7)	982

1960 Jan	89	..	..	..	..	..	..	89 (50·8)	20	..	..	..	..	..	..	20 (11·4)	66 (37·8)	175
Feb	10	..	..	..	..	..	..	10 (40·0)	5	..	..	..	..	..	..	5 (20·0)	10 (40·0)	25
Mar	..	1	15	..	..	..	..	16 (80·0)	..	4	..	..	..	..	..	4 (20·0)	..	20
Apr	14	22	2	..	..	..	..	38 (50·7)	31	6	...	...	..	...	..	37 (49·3)	..	75
May	6	7	..	..	..	..	..	13 (52·0)	6	6	..	..	..	..	..	12 (48·0)	..	25
Jun	..	..	..	14	5	..	..	19 (54·3)	..	..	..	9	7	..	..	16 (45·7)	..	35
July	1	..	..	..	..	..	..	1 (2·0)	..	..	..	..	..	..	..	..	49 (98·0)	50
Aug	32	1	1	4	8	..	..	46 (26·0)	13	..	1	4	10	..	..	28 (15·8)	103 (58·2)	177
Sep	45	2	..	..	6	1	..	54 (56·8)	13	..	..	1	5	5	..	24 (25·3)	17 (17·9)	95
Oct	65	..	..	..	..	9	..	74 (56·5)	42	..	..	..	..	7	..	49 (37·4)	8 (6·1)	131
Nov	60	4	..	..	..	12	16	92 (51·4)	53	..	...	..	..	14	13	80 (44·7)	7 (3·9)	179
Dec	52	..	..	..	..	9	11	72 (43·6)	73	..	..	..	..	11	9	93 (56·4)	..	165
Total	374	37	18	18	19	31	27	524 (45·5)	256	16	1	14	22	37	22	368 (31·9)	260 (22·6)	1152

TABLE III (*Contd.*)

	1								2								3	4
1961 Jan	100	..	..	..	..	..	1	101 (48·1)	108	..	..	..	..	..	..	108 (51·4)	1 (0·5)	210
Feb	67	..	..	..	..	..	..	67 (46·3)	73	..	..	..	..	..	1	74 (50·3)	6 (3·4)	147
Mar	47	..	..	..	..	..	..	47 (46·5)	54	..	..	..	..	..	..	54 (53·5)	...	101
Apr	60	35	..	..	..	..	..	95 (54·3)	78	2	..	..	..	..	..	80 (45·7)	...	175
May	4	34	1	1	..	..	...	40 (53·3)	29	6	..	..	...	..	..	35 (46·7)	...	75
Jun	..	12	31	26	..	..	..	69 (55·2)	..	10	28	17	1	...	..	56 (44·8)	...	125
July	..	..	..	24	9	6	..	39 (52·0)	..	..	2	17	16	1	...	36 (48·0)	..	75
Aug	..	..	..	13	8	17	...	38 (50·6)	...	..	1	9	16	11	...	37 (49·4)	..	75
Sep	..	..	..	..	..	..	...	..	..	..	..	..	...	...	...	..	50 (100·0)	50
Oct	20	..	..	..	..	..	...	20 (13·3)	26	..	...	...	...	...	...	26 (17·3)	104 (69·4)	150
Nov	41	..	..	..	..	..	..	41 (18·2)	23	..	..	...	...	..	..	23 (10·3)	161 (71·5)	225
Dec	84	..	..	..	..	22	..	106 (31·1)	73	..	..	...	..	19	...	92 (27·0)	143 (41·9)	341
Total	423	81	32	64	17	45	1	663 (37·9)	464	18	31	43	33	31	1	621 (35·5)	465 (26·6)	1749

1962	I	II	III	IV	V	VII	VIII	Total	I	II	III	IV	V	VII	VIII	Total		
J	94	..	..	..	..	16	..	110 (40·0)	118	..	..	..	..	9	..	127 (46·2)	38 (13·8)	275
F	101	1	..	..	..	26	..	128 (46·5)	107	..	..	..	..	25	..	132 (48·0)	15 (5·5)	275
M	82	..	..	..	..	..	15	97 (43·1)	114	..	..	..	..	..	10	124 (55·1)	4 (1·8)	225
A	91	2	..	..	..	..	..	93 (53·1)	82	..	..	..	..	..	..	82 (46·9)	..	175
M	88	12	10	1	..	..	1	112 (56·0)	66	8	11	1	..	..	2	88 (44·0)	..	200
J	..	1	14	5	..	..	..	20 (44·4)	..	2	15	..	8	..	..	25 (55·6)	..	45
J	..	..	7	5	..	..	..	12 (48·0)	..	..	13	..	..	..	..	13 (52·0)	..	25
A	—	1	2	18	3	2	...	26 (56·5)	...	...	1	7	12	..	..	20 (43·5)	..	46
S	..	..	..	..	2	11	..	13 (26·0)	..	..	1	..	..	11	..	12 (24·0)	25 (50·0)	50
O	8	..	..	..	..	11	..	19 (9·5)	..	..	..	..	..	14	..	14 (7·0)	167 (83·5)	200
N	109	..	..	..	..	3	..	112 (45·0)	34	..	..	..	..	..	..	34 (13·6)	103 (41·4)	249
D	90	..	..	..	..	25	..	115 (51·1)	58	..	..	..	..	32	..	90 (40·0)	20 (8·9)	225
Total	663	17	33	29	5	94	16	857 (43·1)	579	10	41	8	20	91	12	761 (38·2)	372 (18·7)	1990

TABLE III (*Contd.*)

	1									2								3	4
1963																			
J	9	..	..	..	..	25	..	34 (45·3)	10	..	..	..	..	29	..	39 (52·0)	2 (2·7)	75
F	23	2	..	..	..	49	..	74 (49·3)	26	..	..	..	..	49	..	75 (50·0)	1 (0·7)	150
M	28	18	..	..	..	1	8	55 (55·0)	36	..	..	..	..	2	7	45 (45·0)	..	100
A	15	70	..	..	..	2	46	133 (53·2)	59	18	..	..	..	29	11	117 (46·8)	..	250
M	..	23	19	8	..	..	28	78 (52·0)	16	20	8	9	1	..	18	72 (48·0)	..	150
J	..	2	6	12	2	..	..	22 (29·3)	..	4	18	24	6	..	1	53 (70·7)	..	75
J	..	..	5	30	35	12	..	82 (57·0)	..	..	..	18	44	..	..	62 (43·0)	..	144
A	36	6	1	..	1	..	..	44 (22·0)	46	3	..	..	1	..	..	50 (25·0)	106 (53·0)	200
S	48	..	..	..	..	..	..	48 (50·0)	48	..	..	..	..	..	..	48 (50·0)	..	96
O	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	25 (100·0)	25
N	NO FISHING															..	..	..
D	9	57	1	..	..	..	15	82 (41·0)	91	...	..	..	..	..	27	118 (59·0)	..	200
Total	168	178	32	50	38	89	97	652 (44·5)	332	45	26	51	52	109	64	679 (46·3)	134 (9·2)	1465

1964	I	II	III	IV	V	VII	VIII	Total	I	II	III	IV	V	VII	VIII	Total		
J	..	31	1	..	...	...	13	45 (45·0)	37	..	..	...	..	..	18	55 (55·0)	..	100
F	3	9	..	..	..	..	...	12 (48·0)	13	..	..	..	..	..	..	13 (52·0)	..	25
M	1	15	..	..	..	..	..	16 (64·0)	8	..	..	..	..	..	1	9 (36·0)	..	25
A	..	4	7	..	..	..	..	11 (44·0)	..	4	10	..	..	..	..	14 (56·0)	..	25
M	..	..	7	26	..	..	..	33 (66·0)	..	2	4	11	..	..	..	17 (34·0)	..	50
J	..	..	15	17	24	..	..	56 (56·0)	..	..	3	13	27	1	..	44 (44·0)	..	100
J	..	..	..	6	36	8	..	50 (50·0)	..	..	..	..	48	2	..	50 (50·0)	..	100
A	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	225 (100·0)	225
S	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	345 (100·0)	345
O	111	..	..	..	..	..	..	111 (20·2)	32	..	..	..	..	..	..	32 (5·8)	407 (74·0)	550
N	119	..	..	..	..	..	..	119 (19·8)	5	..	..	..	..	..	..	5 (1·0)	476 (79·2)	600
D	168	..	..	..	..	..	..	168 (30·9)	14	..	..	..	..	..	..	14 (2·2)	362 (66·9)	544
Total	402	59	30	49	60	8	13	621 (23·1)	109	6	17	24	75	3	19	253 (9·4)	1815 (67·5)	2689

TABLE III—(*Concld.*)

	1								2							3	4
1965																	
J · ·	60	..	..	..	..	..	..	60 (13·3)	16	..	..	..	..	1	..	17 (3·7)	373 (83·0)	450
F · ·	154	..	..	..	..	..	..	154 (28·0)	32	..	..	..	..	..	..	32 (5·8)	364 (66·2)	550
M · ·	130	..	..	..	..	..	..	130 (28·9)	22	..	..	..	..	..	..	22 (5·0)	298 (66·1)	450
A · ·	122	6	..	..	..	..	..	128 (36·6)	70	..	..	..	..	..	..	70 (20·0)	152 43.4	350
M · ·	88	146	14	..	..	..	..	248 (45·1)	184	60	14	..	..	1	..	259 (47·1)	43 (7·8)	550
J · ·	..	28	102	3	..	..	..	133 (53·2)	..	27	84	6	..	..	..	117 (46·8)	..	250
J · ·	..	4	82	78	5	..	..	169 (56·3)	..	1	66	58	6	..	..	131 (43·7)	..	300
A · ·	..	18	76	33	13	18	7	165 (34·8)	..	1	73	63	15	32	..	184 (38·8)	125 (26·4)	474
S · ·	78	1	..	..	..	46	57	182 (40·8)	43	..	..	..	1	102	2	148 (33·2)	116 (26·0)	446
O · ·	127	34	..	..	..	..	81	242 (37·2)	134	1	..	..	..	26	30	191 (29·4)	217 (33·4)	650
N · ·	79	117	..	..	..	..	79	275 (37·7)	145	7	..	..	..	..	108	260 (35·6)	195 (26·7)	730
D · ·	64	32	..	..	..	..	9	105 (42·0)	112	7	..	..	..	..	9	128 (51·2)	17 (6·8)	250
Total ·	902	386	274	114	18	64	233	1991 (36·5)	758	104	237	127	22	162	149	1559 (28·6)	1900 (34·9)	5450
Grand Total								5657 (36·55)								4406 (28·47)	5414 (34·98)	15,477

are not insignificant. In 1959 their percentage (of the total examined) was 2.5 which rose to 10.2 in 1960. Their percentages fluctuated in the years 1961, '62, '63, '64 and '65 when the figures recorded were 4.5, 10.7, 24.5, 1.6 and 11.2 respectively. Most of the big individuals by virtue of their higher cruising speed can escape without being caught in the fishing nets giving thereby the impression that they are scarce in the inshore fishing grounds. The observations on the shoaling-behaviour of the species made by the author (Balan, 1961) also support this view.

TABLE IV

Fecundity and sex ratio of various sardines (Sardinella, Sardina and Sardinops)

Species	Authors	Fecundity	Sex Ratio	Remarks
Sardinella maderensis	Ben-Tuvia(1960)	82,000 (quoted from Postel) 1965)	55 females : 45 males (Postel 1955)	Length of female 246 mm.
S. longiceps	Devanesan and Chidambaram (1948) Nair & Chidambaram (1951)	70,000	Below 20 cm. size, ratio equal, females dominated over this size (Chidambaram, 1950). Sex ratio almost equal (Nair, 1960) among Juveniles and spawners.	
	Nair (1960)	75,000 78,000		
S sirm	Nair (1960) quoted from Chacko (1956)	..	Female 2 : male 1	
S. albella	Nair (1960) quoted from Chacko and Mathew (1956)	..	Females dominated.	
S. aurita	Ben-Tuvia(1960) Li Kwan-Ming (1960)	9,757-58,300 large eggs. Range $2 \cdot 86 \times 10^4$ to $2 \cdot 54 \times 10^4$	..	Range of means.
S. fimbriata	Nair (1960) quoted from Chacko (1956)	..	Ratio equal in April; in June female to male 6:4	High range of variations of sex ratios.
	Ronquillo (1960)	37,000 maturing ova (Anicete 1952)	1:1	
Sardina pilchardus	Larraneta (1960)	15,000-50,000 (both ripe eggs and ovoeytes combined) (Andreu 1948)	50 : 50. Dominance of one sex in winter due to changes in school behaviour.	Mean : 29,000 eggs.

TABLE IV (*Contd.*)

Species	Authors	Fecundity	Sex Ratio	Remarks
Sardinops melanosticta	Anon. (Tokai Regional Fisheries Research Laboratory, Tokyo (1960) quoted from Yamanaka & Ito (1957).	About 30,000-100,000	Approximate parity. (Nakai, *et al.* 1955; Yokota & Asami 1957; Yamanaka & Ito 1957).	(Source : Sardine Resources Division contribution B. No. 349).
Sardinops caerulea	Ahlstrom (1960) quoted from MacGregor (1957).	26·8 thousand	1 : 1 (1941 to 1956 females formed 49·4%)	5·14 thousand per increase or decrease of 10 mm. in length, considerable variation in no. of ova for different fish lengths.
S. neopilchardus	Blackburn (1960)	...	1 : 1 in Australia.	
S. ocellata	De Jager (1960)	95,000 in fish of 23 cm. length.	56 females 44 males.	Sex ratio varies; males predominate at 19-22 cm. L. S., females dominate from 22 cm. up; Beyond 22.5 cm nearly all are females.

SUMMARY

Egg counts have been made on 52 mature oil-sardine specimens collected at Cochin coast. The relation between the fish length and the numbers of ripe ovarian eggs is expressed by the formula: $F = 0.9647e^{0.0875L}$. The mature ovary contains, on an average, 48,119 ripe eggs. The relation between the fish weight and the fecundity is expressed by the formula: $F = 2.1263 + 0.0521W$.

The monthly distributions of sexes and maturation stages of the fish, during the years 1959—1965, are presented and the data revealed the preponderance of females in almost all the years which can perhaps be attributed to the separation of sexes effected by the gear (boat-seine) during fishing operations.

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