

## Reproductive biology of *Sardinella longiceps* along Ratnagiri coast off Maharashtra

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Indian oil sardine *Sardinella longiceps* is a highly migratory fish with large scale shoaling along the coast of Ratnagiri. Length weight relationship equations analysed for males were  $W = 0.0350 L^{2.4918}$  females were  $W = 0.0536 L^{2.3410}$ , indeterminants were  $W = 0.0200 L^{2.7021}$  and for combined sexes were  $W = 0.0321 L^{2.5225}$  indicating no significant difference between the sexes of *S. longiceps*. Average GSI values of females were 1.4998 with maximum GSI value 5.4962 in the month of September and minimum (0.4299) GSI value in the month of October. In males the maximum GSI value 4.4962 were observed in the month of September and minimum GSI value 0.2992 were observed in the month of October. Observations reveal that spawning in *S. longiceps* generally takes place only once in a year. Females were always more in number with an average ratio of 1 male:1.1549 females with highest ratio in the month of January. Size at maturity varied from 16 to 20 cm, with occurrence of well developed mature gonads in the months of August-September and spent ones in the months of November to February. Number of mature eggs in the ovaries of the gravid females with the total weight of fish ranging from 50-60 kg varied from 45,000-75,000.

**[Keywords:** *Sardinella longiceps*, Length-weight relationship, Gonadosomatic index, Maturity, Ratnagiri]

### Introduction

Clupeoid fishes, comprising oil sardine, white baits, and lesser sardines contribute about one third of marine fish catches of India. Oil sardine, *Sardinella longiceps* ranks as a very valuable commercial fish owing to its food value and industrial usage for production of fishmeal and oil. In India, oil sardine fishery is confined largely to the west coast though stray catches of the species are also available along the east coast in Tamilnadu and Andhra Pradesh regions. Along the west coast, large shoals of oil sardine occur from Ratnagiri in the north to Quilon in the south, the zone of maximum abundance being the Malabar region<sup>1</sup>.

Oil sardine fishery starts during the southwest monsoon in the month of August and continues up to March, September to December being the peak period of occurrence on the southwest coast of India. The oil sardine shoals first appear in the Calicut region and are then gradually observed in succession towards the north, disappearing towards the end of season in the reverse order. Oil sardine fishery continues to be restricted to a narrow coastal belt within the 50 m depths. UNDP/FAO pelagic fisheries project, which

conducted acoustic and aerial surveys along the west coast of India, concluded that both oil sardine and mackerel shoals occur in neritic waters in the depths of 19 to 40 fathoms. It has been estimated that the average production of oil sardines during the year 2007 was 4.97 lakhs tonnes in India. The sardines rank first in importance and form on an average about 30% of the total pelagic catch<sup>2</sup>. Although the different aspects of biology of oil sardine from west coast of India are dealt by<sup>3-10</sup>, very little is known about the biology of *S. longiceps* from Ratnagiri coast.

### Materials and Methods

Coastal waters of Maharashtra along the west coast of India were selected as study area. Mirkarwada (16°59' 42" North latitude and 73°16' 14" East latitude) a minor fishing harbour on the west coast of India was the sampling station selected for collecting samples of *S. longiceps*. Linear measurements like total length, fork length and standard length were recorded with the help of fish measuring board to accuracy of 0.5 mm. Electronic balance with precision of 0.1mg was used to record the total weight and gonad weight of fish from Mirkarwada

landing center. One thousand specimens were collected during the 2007-08 fishing season to study the various morphometric relationships. This consisted of 381 females in the length and weight range of 15-19.7 cm and 16-66g, 440 females in the length range of 15.2-19.4 cm and 21-69g in weight, 178 indeterminants 11.5-16 cm in length and 13-32g in weight. Each specimen was properly placed on measuring board, after fixing the tip of snout of the specimen to vertical side of measuring board, total length, standard length, fork length were measured. Snout length, orbital diameter, dorsal fin base length, ventral fin length, anal fin base length, pectoral fin base length, anal fin base length, anal fin height, dorsal caudal fin length, ventral caudal fin length, greatest iris diameter, greatest pupil diameter, girth height were measured using standard methods with the help of divider. Total length (LT), Fork length (LF'), Standard length (LS), Snout length (UO), Orbital diameter (OO'), Greatest pupil diameter (Eg), Greatest iris diameter (Ig), Dorsal fin base length (D1D1'), Ventral fin length (Vh), Anal fin base length (AA') Girth height (g), Anal fin height (Ah), Pectoral fin length (Ph), Dorsal caudal fin length (Ch'), Ventral caudal fin length (Ch'') measured<sup>11</sup>.

For GSI estimation the two gonads fused at their base where they are connected to the body cavity were separated by a horizontal cut. The weight of gonads and total body weight was then taken with help of electronic balance. The commonly followed method<sup>12</sup> is expressed as

$$\text{GSI} = \text{gonad weight} / \text{body weight} \times 100$$

Specimens of different sizes, collected at random, were dissected to examine the sex by examining the gonads since no external characters are known to distinguish males and females. Sex ratio was worked out. All maturity stages were observed with help of colour and shape of ovary as reported earlier<sup>12</sup>. In the present studies fecundity of fish was determined for 4 specimens ranging from 15 to 20 cm in total length and 50 to 65 g in total weight by volumetric method. A sample of 2 mg mature ovary was weighed with an electronic balance of 0.1 mg accuracy. The sample was then taken in a watch glass and number of mature ova in the sample were counted physically. The fecundity was determined by the formula<sup>13</sup>.

$F = \text{TW} / \text{SW} \times \text{number of ova of penultimate stage counted in the sample}$

where,

F= Fecundity

TW= Total weight of the ovary

SW= sample weight

The maturity stages of females of *S. longiceps* in different months shown in table no 4.

## Results and Discussion

### Morphometric Characteristics

Morphometric characters of all the fish collected during present investigation have been worked out and compared. The various body part measurements of the fish have been computed and are given in Table 1. Characters with total length were analysed to find out the degree of correlation. The comparative account of various relationships between different morphometric measurements have been indicated by Table 1.

Independent statistical analysis of their length and weight relationship gave the following regression equations.

1. Males:  $W = 0.0350 L^{2.4918}$   
(Fig. 1)
2. Females:  $W = 0.0536 L^{2.3410}$   
(Fig. 2)
3. Indeterminate:  $W = 0.0200 L^{2.7021}$   
(Fig.3)
4. Combined:  $W = 0.0321 L^{2.5225}$   
(Fig.4)

Table 1—Linear regression coefficients for the relationship of total length (LT) and various body parts for *S. longiceps*

Sr. No.	Characteristics Compared with Total length (LT)	Regression parameters		
		a	b	r
1	LF'	-0.8133	0.8822	0.9045
2	LS	4.4485	0.4545	0.5819
3	UO	0.2421	0.0505	0.7522
4	OO'	0.4415	0.0189	0.6092
5	Eg	0.0504	0.0212	0.7552
6	Ig	-0.3523	0.0661	0.5416
7	D1D1'	-0.0234	0.1062	0.7561
8	Vh	0.5637	0.0333	0.5297
9	AA'	0.3545	0.0807	0.6227
10	g	0.0999	0.2162	0.1278
11	Ah	0.2404	0.0247	0.5365
12	Ph	-0.8820	0.1698	0.6061
13	Ch'	0.0122	0.1725	0.8241
14	Ch''	0.1953	0.1897	0.8805

The analysis of covariance indicated that there was no significant difference in the slopes of male, female and indeterminate samples ( $P > 0.05$ ). The t-test was employed to test for the growth isometric.. The estimated 'b' values indicated allometric growth in males, females and total samples ( $P < 0.05$ ), whereas the indeterminants showed isometric growth ( $P > 0.05$ ).

GSI were calculated monthwise which showed high and low values in either sex (Table 2). High values in August-September suggested maturity of gonads during these months. Therefore, it can be inferred that the spawning of *S. longiceps* occurred

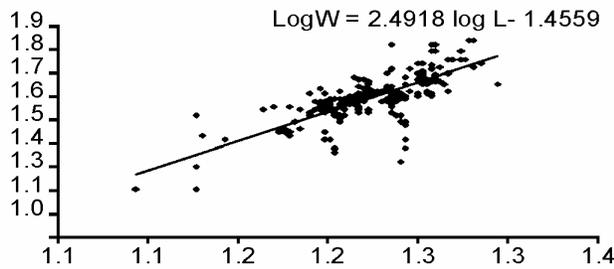


Fig. 1—Logarithmic relationship between length and weight in the male of *S. longiceps*

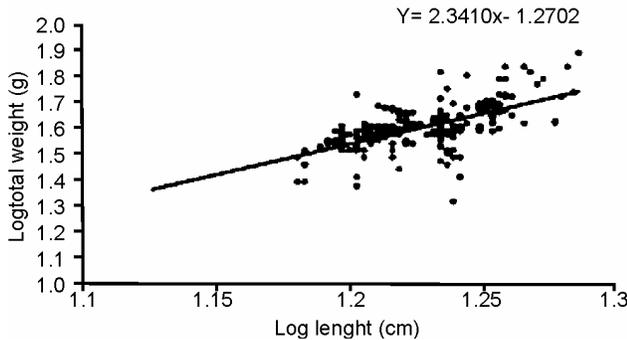


Fig. 2—Logarithmic relationship between length and weight in the female of *S. longiceps*

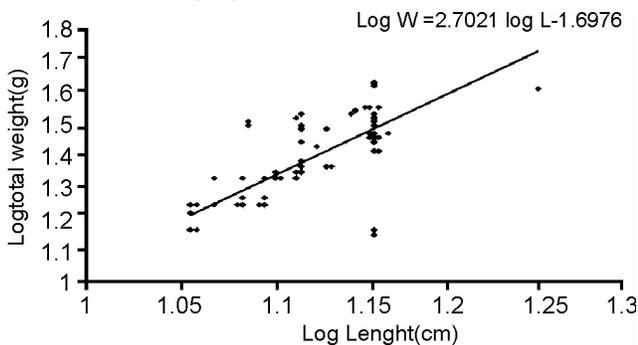


Fig. 3—Logarithmic relationship between length and weight in the indeterminants of *S. longiceps*

only once in a year. The values of GSI was high at 15 cm in total length for either sex, with the total absence of mature fish during October-March.

Sex composition of the random samples examined during each month from April 2007 to March 2008 has been represented in Table 3. Females were almost always more in number with an average ratio of 1 male:1.1696 females. The observations reveal that females outnumbered males in all the months with highest ratio in the month of January. Chi square test revealed that there was no significant difference in number of males and females in various months ( $P > 0.05$ ).

In all 480 ovaries, at different stages were examined. It was seen that maturity stages I, II, and III occurred in November to February. The stages IV and V occurred in month March to May. Fully mature stages VI and VII were observed in August and September Table 4. A total of 54 ovaries were examined histologically of the samples collected during the period April 2007 to May 2008. The diameter of oocytes and frequency distribution of oocyte sizes were assessed from different developmental stages. Thus spawning season generally appears to be short from July to September.

The fecundity range in female of *S. longiceps* was recorded as 45,000 to 75,000 in month of August at the size range 15 to 20 cm and 0.050 to 0.065 kg in total weight.

In the present study, the total length of *S. longiceps* collected along the Ratnagiri coast ranged from 11-20 cm. The total length of oil sardine ranged from 2.5 to 18.7 cm along the Mangalore coast<sup>14</sup>. Whereas the length of *S. longiceps* along the Kerala and Karnataka coast ranged between 5-21.5 cm<sup>15</sup>. The average values of total length reported by various workers were almost similar in comparison to the total length recorded in the present study. In the Ratnagiri area larger size fish occur as compared to south west coast of India as the major spawning grounds are available along the South West coast of India and the fish then migrate towards the North West coast of India due to which larger size fish ranging from 17-20 cm were recorded along Ratnagiri coast.

The morphometric equations for the samples collected along the Ratnagiri coast were  $SL = 4.4484 + 0.4544 LT$ ,  $LF' = 0.8133 + 0.8822 LT$ ,  $UO = 0.2421 + 0.0505 LT$ ,  $OO' = 0.4415 + 0.0189 LT$ ,  $D1D1' = -0.0234 + 0.1062 LT$ ,  $Vh = 0.5637 + 0.0332$

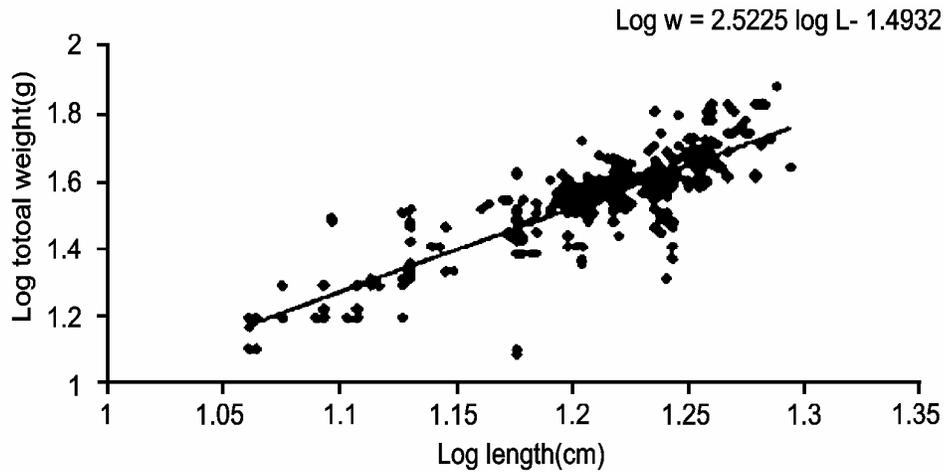


Fig. 4—Logarithmic relationship between length and weight in the males, females and indeterminants of *S. longiceps*

Table 2—Monthly average GSI values of males and females of *S. longiceps* from April to March

Sex	April	May	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Average
Males	0.4051	0.5469	3.0826	4.4962	0.2992	0.3595	0.6793	0.7457	0.3855	0.4243	1.1421
Females	0.4659	0.5469	5.1534	5.4962	0.4299	0.3809	0.9614	0.4526	0.6367	0.4745	1.4998

Table 3—Month wise sex ratio of *S. longiceps* along Ratnagiri coast

Sr. No.	Months	Males	Females	Sex Ratio (M:F)
1	April	43	45	1:1.0465
2	May	42	51	1:1.2143
3	August	36	39	1:1.0833
4	September	41	55	1:1.3415
5	October	47	48	1:1.0213
6	November	42	46	1:1.0952
7	December	26	32	1:1.2307
8	January	26	38	1:1.4615
9	February	33	36	1:1.0909
10	March	45	50	1:1.1111
	Total	381	440	1:1.1696

Table 4—Maturity stages of females *S. longiceps* in different months along Ratnagiri coast

Months	Maturity stages
November to February	Stages I, II, III
March to May	Stage IV, V
August to September	Stages VI, VII

LT, Ph = -0.8820 + 0.1677 LT, AA' = 0.3545 + 0.0806 LT, Ah = 0.2403 + 0.5365 LT, Ch = 0.0121 + 0.1725 LT, Ch' = 0.1953 + 0.1896 LT, Ig = -0.3523 + 0.0661 LT, Eg = 0.0504 + 0.0211 LT, g = 0.0999 + 0.2162 LT. As none of the authors have reported relationships between LT and LF', UO, OO', D1D1, Vh, Ph, AA', Ah, Ch, Ch', Ig, Eg, therefore the results of the present studies cannot be compared with the earlier reports.

The pooled length weight relationship of *S. longiceps* along Ratnagiri coast was  $W = 0.0321 L^{2.5225}$ . The a and b values of the length-weight relationship for males were 0.0350 and 2.4918 respectively and for females were 0.0536 and 2.3410 respectively and for indetermined sex were 0.0200 and 2.7021 respectively. In comparison the length-weight relationship b values in *S. longiceps* were 3.1729, 3.5034, 2.8762 and 3.1890 for males, females, unsexed fish and total fishes respectively<sup>16</sup>. The length weight relationship studies of *S. longiceps* conducted of *S. longiceps* on west coast of India<sup>10</sup>. The estimated regression coefficients in the present study for Ratnagiri specimens were very close to three for the indeterminants and were indicating isometric growth, whereas the males, females and

total values indicated allometric growth for *S. longiceps*.

In the female specimens of *S. longiceps* found along the coast of Ratnagiri maximum GSI observed was 5.4962 g in the month of September and minimum GSI observed was 4.299 g in the month of October. GSI of *S. longiceps* found along the Gulf of Aden<sup>17</sup>, did not exceed 1% of body weight in the months of November-May and from May to July the GSI increased by 7.5% of body weight. The comparisons done with earlier studies reveal that variation in GSI values in different months and seasons may be due to migration of *S. longiceps* at long distances for spawning and variation in spawning season.

Sex ratio indicated the females outnumbered males with an average ratio of 1 male: 1.1696 females. Monthwise analysis of sex ratio showed that number of females was higher in the months of January and September whereas indeterminate sex were higher in the months of December and January. Length wise distribution shows both sexes occur more or less in equal numbers up to a size of about 20 cm and thereafter there is a slight predominance of females in certain regions<sup>18</sup>. Males were dominant in the month of June and females dominated in the months of February, July and December<sup>15</sup>.

In the present study, 480 ovaries were examined. It was observed that maturity stages I, II, and III occurred in the months from November to February. The stages IV and V occurred in the months from March to May. Fully mature stages VI and VII were observed in the months of August and September. According to the present study spawning season generally appears to be from July to September. Immature fish (stage I and II) dominated the catches in the months from August to November, in the months of December to January, maturing (stage III) fish dominated the catches and in the months of April, May and June maturing and matured fish dominated catches of *S. longiceps* along the Mangalore coast<sup>19</sup>. Maturity stages III to V occurred from May to June regularly and partly spent fish having narrow and flabby gonads were met within good numbers in August. Occurrence of spent fish was observed from September onwards of *S. longiceps* along the Cochin coast<sup>8</sup>.

Hornell<sup>20</sup> observed that the spawning season in *S. longiceps* extends from the end of June to the end of

August. According to him spawning is a little earlier in north than in south since the shoals of mature oil sardine arrive earlier off the South Kanara coast. The south west monsoon is an important factor influencing the entry of spawners into the coastal waters and consequently the spawning season shows a tendency to shift depending on the early or late onset of the monsoon<sup>21</sup>. This observation is corroborated by the differential rate of growth during the first year. The spawners enter the coastal waters after the commencement of the monsoon generally during June and July. Intensive spawning of oil sardine generally takes place during August and September<sup>21</sup>. In the present study results were almost similar with peak spawning during the months of July-September due to short monsoon period from June to September.

The fecundity of *S. longiceps* ranged from 45,000 to 75,000 along the Ratnagiri coast. Jaiswal<sup>18</sup> and Balan<sup>22</sup> reported the fecundity of this species as 70-75 and 37-80 thousand eggs respectively. It is clear from the above observations that fecundity of *S. longiceps* is nearly same at various locations on west coast of India.

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