

Some aspects of spawning season and biology of Indian Oil sardine, *Sardinella longiceps* along, Goa – Karwar sector of West Coast of India

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The parameters of the length-weight relationship of the form $W = aL^b$ are presented for *S. longiceps*, caught along the Goa and Karwar West coast of India. Samples from commercial (trawl, purse seines, and gill nets) and artisanal gears were collected during June to October 2013. Length weight relationship for males collected from Goa were $W = 0.0109L^{2.92}$, females were $W = 0.019L^{2.80}$, and for combined sexes were $W = 0.0142L^{2.87}$. Length weight analysis for the specimens collected from Karwar showed that males were $W = 0.0054L^{2.82}$, females $W = 0.0174L^{2.85}$ and combined $W = 0.0109L^{2.98}$ respectively. In Goa, females with maximum GSI value of 5.8073gm were observed in the month of June while minimum was 3.730gm in the month of August. It has been that in Karwar, maximum GSI of 7.557gm and minimum of 4.094 gm in the months of August and September were observed respectively. Number of mature eggs in the ovaries of the gravid females of fish ranging from 55,000 to 76,000 Goa and 50,000 to 80,000 for sardines collected from Goa and Karwar, respectively.

[Keyword: *Sardinella longiceps*, reproductive biology, Goa and Karwar, Arabian Sea]

Introduction

The Indian oil sardine, *Sardinella longiceps* Val., is a major neritic pelagic fishery resource of the country. It has a wide distribution along the coasts of Seychelles, Somalia, Africa, Pakistan, India and Philippines. Along the Indian peninsula, the resource has been predominant along the southwest coast between 8°N and 16°N latitudes covering Kerala, Karnataka, Goa and southern part of Maharashtra Annigiri *et al*¹ Investigations on the oil Sardine have been carried out in India since 1908 when Hornell made his preliminary survey, and the summary of the important results obtained by Hornell and Nayudu was published in 1924 Panikkar². Considerable work has been carried out on the fishery and biology of oil sardine of the west coast of India Nair³, Sekharan⁴, Bensam⁵, Antony Raja⁶, Radhakrishnan⁷, Annigiri⁸, Prabu and Dulkhed⁹, Sam Bannet¹⁰, Deshmukh *et al*¹¹ The oil sardine fishery off the Malabar Coast of India is a commercially important fishery due to food value and industrial uses for sardine oil, fertilizers, and canning. It contributes significantly to the marine fish landing of India, and forms the mainstay of Indian Pelagic fisheries along the west coast. This fishery exhibits dramatic fluctuations from year to year Xu and Boyce¹². Annual marine fish landings for India registered an all time high of 3.94 million metric tonnes during the year 2012. It has been estimated that the average production of oil sardine during the year 2012 was 7.20 lakhs tonnes in India. The sardines rank first in importance and form on

an average about 18.2% of the total pelagic catch Anon¹³. Sex ratio studies are important and provide basic yet vital information for assessing the reproductive condition of the fish stock Wang *et al*¹⁴, Vicentini and Araújo¹⁵, Al-Jufaili¹⁶. Since the Goa and Karwar area falls in active Sardine fishery region, any change in the reproductive biology of sardine in this area will make a vast change in the annual production of sardine. In view of this, the data collected at Goa and Karwar have been analysed to elucidate the relationship of reproductive biology *S. longiceps* and results are presented.

Materials and Methods

Sampling were conducted along Goa (15° 25'N to 15° 3'N; 73° 43'E to 73° 55'E) and Karwar coast (14° 50'N; 73° 54'E) (Fig.1) during the year 2013. In Goa and Karwar, all major and minor fishing harbors are situated on the west coast of India, these stations were selected for collecting samples of *S. longiceps*.

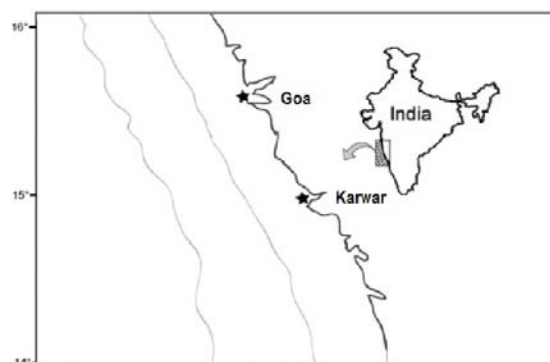


Fig.1: Location of the study sites

Sardine samples were collected monthly on random basis from landing centers during June to October 2013. Samples collected were preserved in cool box with ice flakes and were analysed on the same day of sampling. 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.

A total of 290 and 227 no of specimens were collected during the June to October 2013 to study the spawning season and reproductive biology. 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, fork length and standard length were measured. For gonado-somatic index estimation, the two gonads fused at their base where they are connected to the body cavity were separated by horizontal cut. Weight of gonads and total body weight were taken with help of electronic balance. Commonly followed method for finding out gonado-somatic index¹⁷ and is expressed as

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

Specimens were dissected to examine the sex by examining the gonads since no external characters are known to distinguish males and females and the sex ratio were worked out. All maturity stages were observed with the help of colour and shape of ovary as reported earlier Bal and Rao¹⁷. 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 numbers of mature ova in the samples were counted physically.

In the present study, fecundity of fish was determine from the Goa region size ranging from 18 to 19.60 cm in total length and 52 to 75.990 gm while at Karwar region ranging from 18.00 to 20.5 cm in total length 66.9 to 82 gm in total weight.

The fecundity was determined by the formula Garg *et al*¹⁸.

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

Where,

F = Fecundity

TW = Total weight of the ovary

SW = sample weight

Maturity stages of females of *S. longiceps* in different months shown in Table 3

Results

During the study period, a total of 292 sardines were collected from Goa and 227 from Karwar. 136 male sardines were sampled from Goa and their lengths ranged from 151.0 to 206 mm (with a mean of 172 ± 1.6 mm). 154 female sardines were sampled and their lengths ranged from 152 to 205 mm (with a mean of 171.9 ± 2.02 mm.) 105 male sardines were sampled from Karwar and their lengths ranged 153 to 206 mm (with a mean of 169 ± 1.4 mm.). 122 female sardines were sampled and their lengths ranged from 150 to 205 mm (with a mean of 168 ± 2.1 mm). Lengths of male and female sardines were statistically proved to be not different ($P < 0.05$). During the study period the weights of the male sardines from Goa were ranged from 31 to 86.86 gm (with a mean of 41.34 ± 0.57 gm), whereas for females the weights ranged from 34.30 to 86.86 g (with a mean of 38.33 ± 0.52 gm). At Karwar station weights of the male sardines ranged from 30.12 to 85.26 gm, (with a mean of 38.33 ± 0.52 gm,) whereas for females the weights ranged from 35.67 to 85.00 gm (with a mean of 38.33 ± 0.52 gm). Total weight of male and female sardines proved to be not statistically different ($P < 0.05$).

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

In Goa:

1. Males: $W = 0.012L^{2.92}$
(Fig. 1a)
2. Females: $W = 0.017L^{2.80}$
(Fig. 1b)
3. Combined: $W = 0.0142L^{2.87}$
(Fig. 1c)

In Karwar:

4. Males: $W = 0.0167L^{2.82}$
(Fig. 2a)
5. Females: $W = 0.0155L^{2.85}$
(Fig. 2b)
6. Combined: $W = 0.0109L^{2.98}$
(Fig. 2c)

The 'b' value obtained for both male and female for Goa and Karwar was found to be 2.92, 2.80 and 2.82, 2.85, respectively and it was found to be statistically insignificant from the isometric value 3 (*t*-test, $P < 0.005$). All these results confirm that both male and female *S. longiceps* from Karwar and Goa showed an isometric growth pattern. Length weight relations showed no significant difference between male and female (ANCOVA).

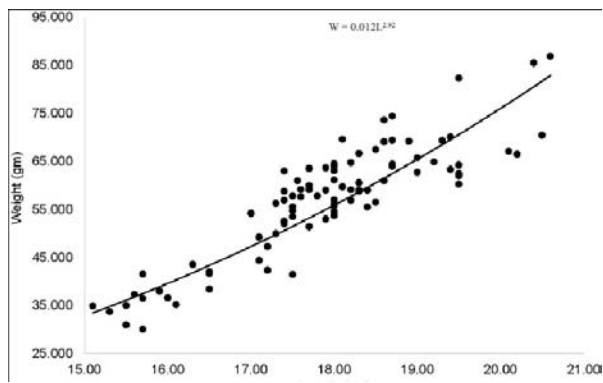


Fig 1. Logarithmic relationship between length and weight in the male of *S. longiceps* along Goa coast.

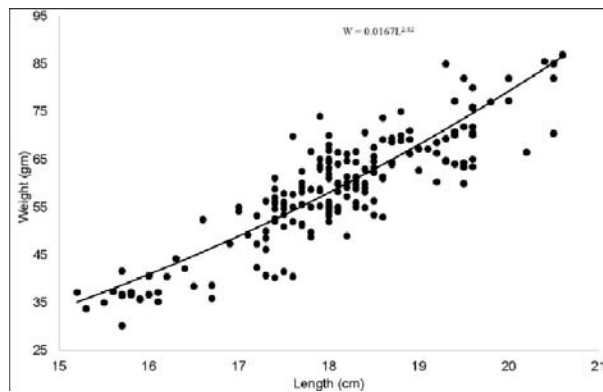


Fig 4. Logarithmic relationship between length and weight in the male of *S. longiceps* along Karwar coast.

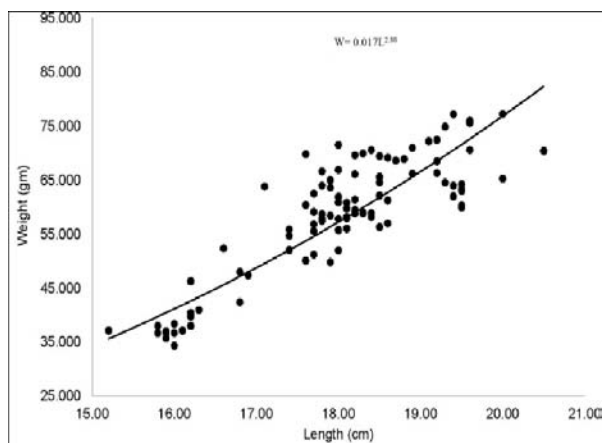


Fig 2. Logarithmic relationship between length and weight in the female of *S. longiceps* along Goa coast.

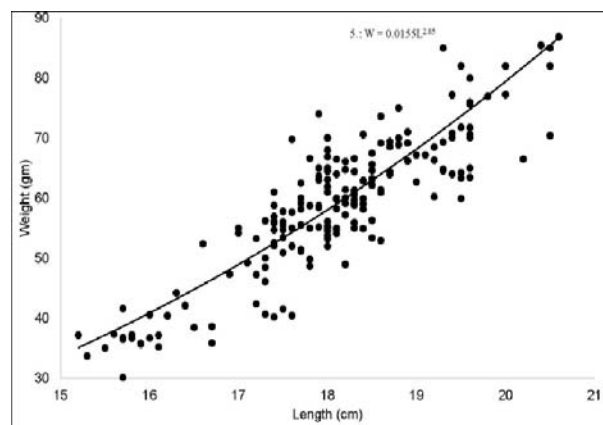


Fig 5. Logarithmic relationship between length and weight in the female of *S. longiceps* along Karwar coast.

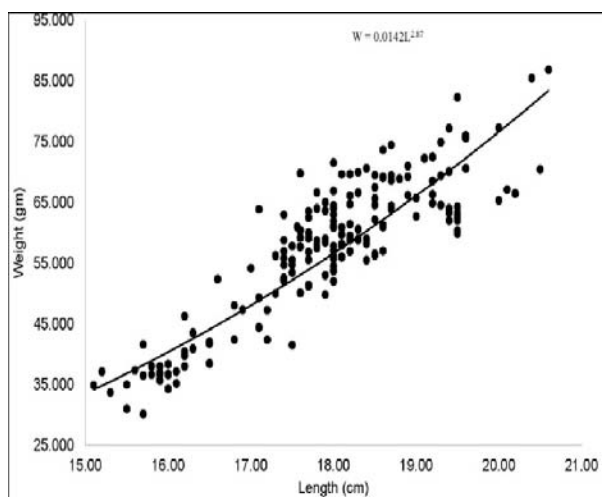


Fig 3. Logarithmic relationship between length and weight in combined sex of *S. longiceps* along Goa coast.

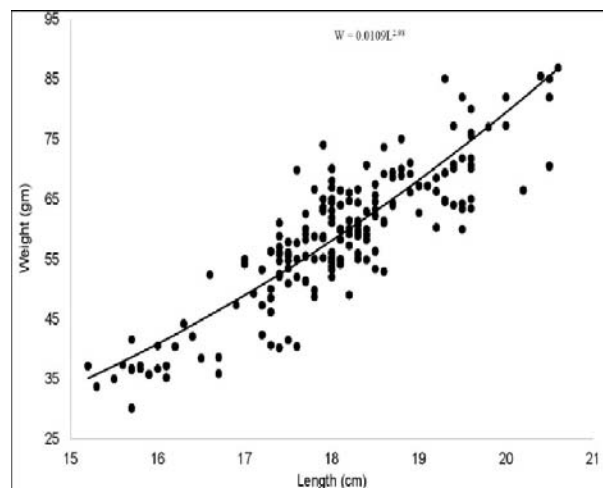


Fig 6. Logarithmic relationship between length and weight in combined sex of *S. longiceps* along Karwar coast.

Table 1. Monthly average GSI values of males and Females of *S. longiceps* along Goa and Karwar coast.

Months	Goa		Karwar	
	Male	Female	Male	Female
June	6.274	5.8073	-	-
August	5.758	3.730	8.687	7.557
September	5.861	4.1553	6.227	4.094
October	4.068	3.895	6.664	4.937
Average	5.490	4.396	7.192	5.529

GSI were calculated month wise, which showed high and low values in sex. High and low values in June to September suggested maturity of gonads during these months. Therefore, it can be inferred that the spawning of *S. longiceps* occurred only once in a year (Table: 1). Sex composition of samples examined during each month from June to October 2013 has been represented. Sex ratio of male to female sardine was found to be 1: 1.132 and 1:1.1025 for Goa and Karwar, respectively (Table 2).

Table 2. Month wise sex ratio of *S. longiceps* along Goa and Karwar coast.

Months	Goa			Karwar		
	Male	Female	Sex ratio	Male	Female	Sex ratio
June	27	30	1:1.111	-	-	
August	39	41	1:1.051	13	15	1:1.153
September	36	47	1:1.305	51	56	1:1.098
October	31	39	1:1.258	45	61	1:1.355
Average	133	157	1:1.180	109	132	1:1.211

Females were more in number during sampling period. The observation revealed that females outnumbered males in all months with highest ratio in the month of September and October for Goa and Karwar, respectively. Chi square test revealed that there was no significant difference in sex ratio during the study period ($P > 0.05$).

In the present study a total of 157 and 132 ovaries were examined for Goa and Karwar stations. It was observed that, maturity stages IV, V, VI, VII, VII spent observed during the months from June to October. Fully mature stages VI and VII were observed during the months of June and August (Table. 3). According to the present study spawning season appears to be from July to September. More number of spent fish was observed from September and October. The fecundity of *S. longiceps* in the month of August ranged from 55000 to 76000 along the Goa and

50000 to 80000 along Karwar at size range from 52 to 75.99 gm and 66.9 to 82 gm in Goa and Karwar respectively.

Table 3. Maturity stages of females *S. longiceps* in different months along Goa and Karwar coast.

Months	Maturity stages	
	Goa	Karwar
June	IV, V, VI	-
August	III, IV, V, VI, VII	V, VI, VII, VII-spent
September	V, VI, VII, VII-spent	V, VI, VII, VII-spent
October	V, VI, VII, - spent	V, VI, VII, VII-spent

Table 4. Last 4 years fish production of oil sardine from Goa and Karwar.

S. No.	Year	Total Production of Goa	Total Production of Karwar
1	2009	21946	25366.7
2	2010	21856	24509.53
3	2011	23120	33771.28
4	2012	32315	30827.95

Landing recorded from 2009 to 2012 from Goa and Karwar region is given in Table 4 and 5. Monthly landing for consecutive four years showed an increase in sardine catch in Goa and Karwar region except in 2012, where decline in sardine catch in Karwar region. Also the catch recorded is higher in Karwar then Goa. The trend of fish landing showing an increase in Karwar region compared to Goa, indicated that, *S. longiceps* migrates from south to north west coast of India. In months June and July fish landing were low due to fishing ban. August onwards fish landing were increased.

Discussion

In the present study, the total length of *S. longiceps* collected along the Goa and Karwar coast ranged from 151 to 205 mm and 15 to 206 mm respectively. Abdurahiman *et al*¹⁹ reported oil sardine from Mangalore coast with total length ranging from 115 to 212mm during August 1999 to May 2001. Shah²⁰ reported total of 917 specimens of *S. longiceps* in the length range of 114 to 212 mm and weight range of 11.52 to 86.82gm were collected at random on monthly basis from Mirkarwada landing center of Ratnagiri Maharashtra. When compared with Goa and Karwar fish size data, it was observed that size of fish is larger compared to fish size reported along south west coast of India and fish then migrate towards the North West coast of

India due to which larger size fish ranging from 160 to 200 mm were recorded along Goa and Karwar coast.

Values of exponent 'b' provide information on fish growth. When $b=3$ increase in weight is isometric. i.e., length increases in equal proportion with body weight. When the value of b is other than 3, weight increase is said to be allometric (positive if $b>3$ and negative if $b<3$) Shah *et al.*²⁰. The b values of the length-weight relationship in present study for Goa and Karwar below 3 that is the growth is negative allometric, female sardines in both regions showed negative allometric growth while only male sardines of Karwar showed positive allometric growth pattern. Male sardines of Goa are very close to isometric growth pattern. Negative allometric growth shows that the fish favour increase in length than in weight, that is, the fish becomes slender as it increase in length. Haruna and Bichi²¹ opined that negative allometric growth means that the fishes could grow non-valuable parts such as fins and head at the expense of the valuable trunk. Shah²⁰ reported length-weight relationship of *S. longiceps* in Ratnagiri region during October 2010 to May 2012 where he indicated negative allometric growth in sardines during that period.

In the female specimens of *S. longiceps* found along the coast of Goa and Karwar, maximum GSI observed was 5.8073 gm during the month of June and minimum GSI observed was 3.730 gm in the month of August. In case of Karwar, maximum GSI was 7.557gm and minimum was 4.094gm in the months of August and September. Antony Raja²² reported average weight of mature ovary 6.5 gm in the months July to September and running stage ovary 9.0 gm weight in the months July to October. Al-Anbouri²³ studied GSI of *S. longiceps* at Oman coast which showed two spawning seasons: the minor from December to March and the major once from June to September. The maximum GSI attained between 5.0 and 5.2 during June and September respectively, suggesting a spawning peak occurred during that period.

Sex ratio indicated the females outnumbered males with an average ratio of 0.88 in Goa and 0.99 in Karwar. Month wise analysis of sex ratio showed that number of females was higher in the all months. Annigeri¹ has also reported that, in Goa and Karnataka, sex ratio of oil sardine was 0.88 and 0.92, respectively. Jufaili²⁴ reported an overall mean sex ratio of 0.68 of Indian oil sardine in waters off Oman as 0.68 during year 2005 to 2008

According to the present study, spawning season generally appears to be from July to September. Partly spent fish having narrow and flabby gonads were met within good numbers in August. Occurrence of spent fish was observed from September onwards by Gopinathan²⁵ along the Cochin coast while studding *S. longiceps*. Annigeri⁸ reported availability of mature specimens from May to September naturally indicates the prolonged nature of spawning in this species. 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. Variable spawning season of sardines from one year to another was reported by Jufaili²⁴ starting from June to October when he studied Indian oil sardine in waters off Oman for 5 successive years (2004-2008).

The fecundity of *S. longiceps* ranged from 55000 to 76000 thousand along the Goa and 50000 to 80000 thousand along Karwar respectively. Deshmukh¹¹ reported that fecundity of *S. longiceps* from 45,000 to 75,000 thousand along Ratnagiri coast. Jaiswal²⁶ and Balan²⁷ reported the fecundity of this species as 70000-75000 and 37000-80000 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. Earlier estimates of the fecundity of this fish have varied between 37,000 to 80,000, Devanesan²⁸, Nair and Chidambaram²⁹, Nair³, Balan³⁰ and Antony Raja³¹.

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