

Studies on the reproductive biology of Indian Sand Whiting *Sillago sihama* (Forsskal)

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Sillago sihama have a prolonged breeding season from June to December, with spawning activity peaked during the period of September to November. Length at first maturity stage was found to vary between 155-164 mm (total length) in both sexes. Although overall sex ratio indicated predominance of female, Chi-square test (χ^2) showed no significant difference throughout the year. Fecundity varied from 11,376 to 103,695 per fish, is significantly correlated with total length ($r = 0.85$, $p < 0.01$), body weight ($r = 0.88$, $p < 0.01$) and ovary weight ($r = 0.87$, $p < 0.01$).

[Keywords: *Sillago sihama*, Reproduction, Spawning, Fecundity, Sex ratio]

Introduction

The reproductive cycle of fishes is closely tied to the environmental changes particularly temperature, photoperiod and food supply¹. Reproductive parameters such as size at first maturity, spawning frequency, fecundity, sex ratio, and recruitment of stock are of great value in fishery resource management² and also essential and important in aquaculture practices. The availability of quality seeds and the ability to control fish reproduction are widely recognized as limiting factors in the farming of any commercial species.

Information available on the reproductive biology of the estuarine fish, *Sillago sihama*, *Sillaginidae* from Indian waters, particularly from Goa waters is scanty. Hence a detailed investigation on reproductive biology was conducted and the results are presented in this paper.

Materials and Methods

Fish samples were collected at fortnightly intervals from Zuari estuary (off Dona Paula) over a period of 15 months (January 2004-April 2005). Samples were cleaned and the surface moisture was removed using tissue paper in the laboratory. Each fish sample was then measured for its total length to the nearest 1 mm and total weight to the nearest 1 g. Sex of individual specimen was determined by gross appearance of gonadal structures. Maturity stages of each gonad were recorded on the basis of morphological appearance (macroscopic observations) in both sexes;

microscopic observations were also used in case of female. Intra-ovarian oocyte diameter was measured using an ocular micrometer. Oocytes were grouped into three O.M.D intervals. Oocyte diameter frequencies from the ovaries of the same maturity stages were pooled and plotted to study the ova development. Frequency of spawning was determined following the criteria given by Jayabalan³. Spawning season was determined from the annual changes in gonadal stage composition of both sexes and gonadosomatic index (GSI). Fishes belonging to maturity stage III onwards have been considered as mature fish and used for determining the size at first maturity. The length at which 50% of fish were mature was considered as length at first maturity. Sex ratio was calculated for different months and size groups of the fish, and was tested for equality for using Chi-square test. Fecundity was studied by examining 30 matured preserved ovaries. Mature oocytes were counted and the total number of oocytes was computed based on the total weight of the ovary using the formula:

Total Fecundity (F) =

$$\frac{\text{No of ova in the sample} \times \text{Total weight of ovary}}{\text{Weight of the sample}}$$

Relationship between fecundity and total length, total weight and weight of ovary statistically determined using the formula:

$$\text{Log F} = A + b \text{ Log X}$$

where F denotes fecundity, X is total length, total weight and ovary weight, and 'a' and 'b' are constants.

Results

Classification of maturity stages: Gonads of adult fishes were classified into five maturity stages based on gonads morphology in male, morphology in addition to intra-ovarian ova in female following the description given by Jayasankar⁴.

Following the classification suggested by Hyndes et al.⁵, four stages of oocytes could be distinguished in the ovaries of *S. sihama*, they are:

Proneuclear oocyte (Immature): Transparent, with a prominent central nucleus ova ranged between 0.02-0.05 mm.

Yolk-vesicle oocyte (Maturing): Small, opaque in which the yolk deposition just started. The oocyte diameter varies from 0.14-0.22 mm in early stage to 0.22-0.35 mm in late stage.

Yolk granule oocyte (Mature): Large, opaque, spherical full yolked. The ova diameter ranged between 0.32-0.44 mm, up to 0.47 mm in few instances

Hydrated eggs (Ripe): Fully mature, large, fully or partially transparent which have burst from the follicles. Varied in diameter from 0.44 to 0.50 mm, very few instances were found up to 0.62 mm.

Oocyte maturation

The size frequency distribution of oocytes in the stages I - V of maturity are shown in Fig. 1. Presence of three distinct modes of ova in mature ovary besides the immature stock, indicates that *S. sihama* from Goa waters spawns 3 times a year. This is supported by a sustained high GSI value coinciding with the same period.

Size at first maturity

Percentage occurrence of matured individuals was plotted against different size group in male and female and the same is given in Fig. 2. It showed that both sexes became mature at a size group of 155-164 mm total length. All males measuring more than 175 mm were matured, while, in female, it was 185 mm. However, the smallest size at which mature specimens were found was 138 mm and 135 mm in male and female, respectively.

Percentage occurrence of different maturity stages of male and female are shown in Fig. 3. From the

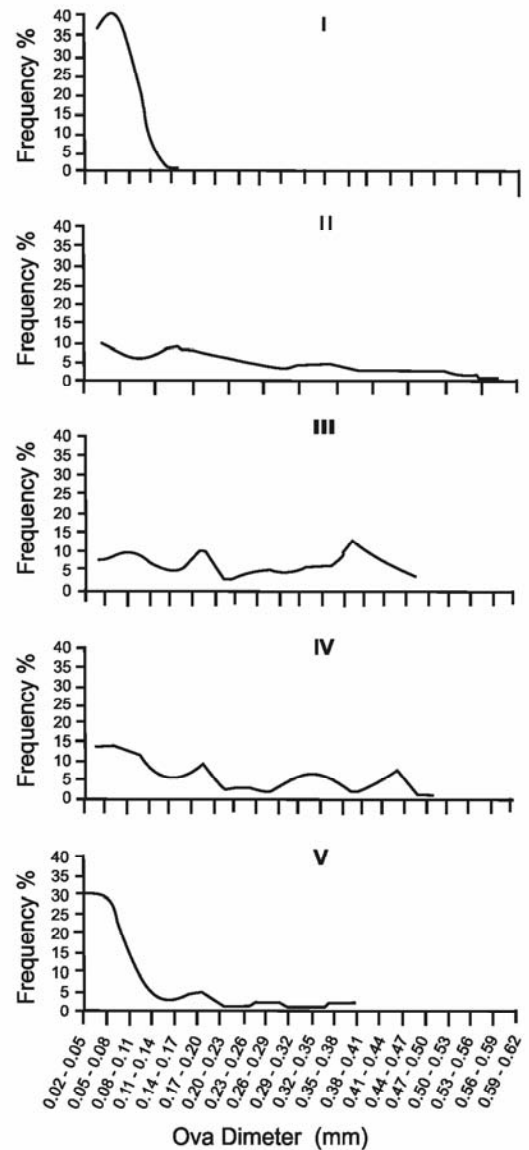


Fig. 1—Ova diameter frequency polygons of different maturity stages in *S. sihama*

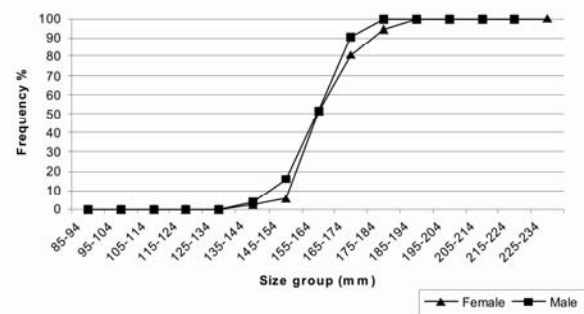


Fig. 2—Percentage occurrence of male and female *Sillago sihama* in different size groups

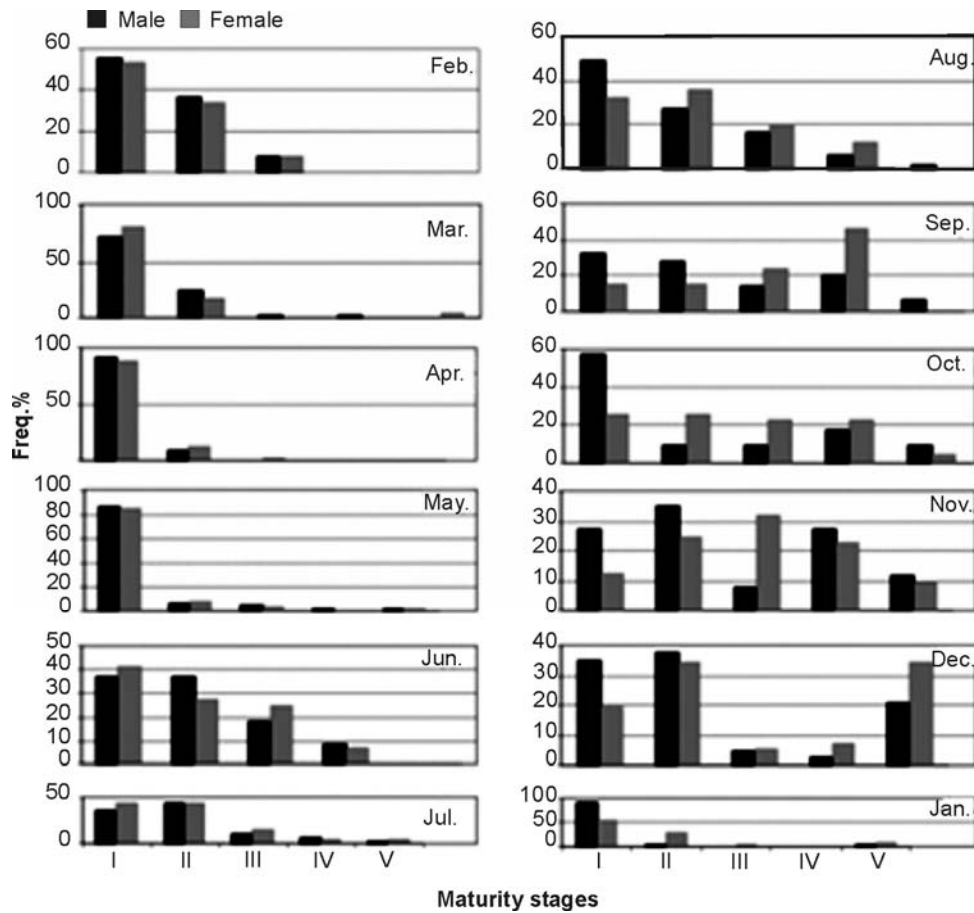


Fig. 3—Percentage occurrence of male and female *Sillago sihama*

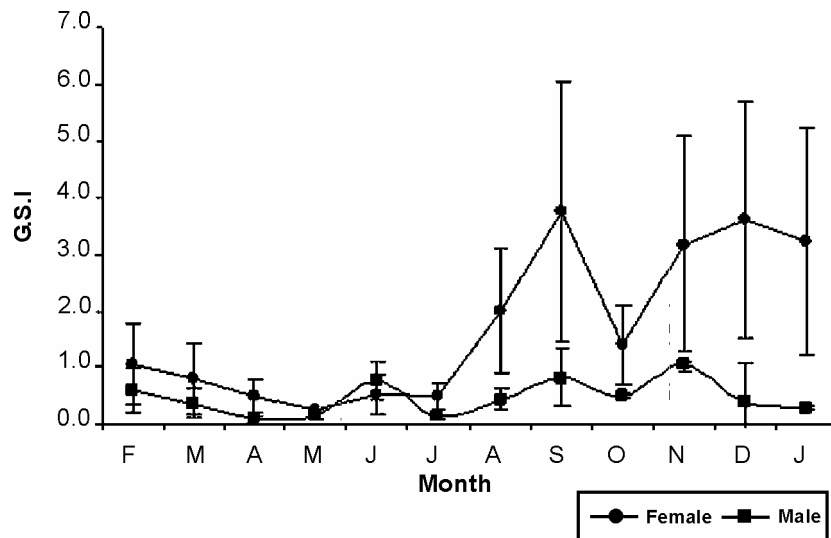


Fig. 4—Monthly mean gonadosomatic index values of *Sillago sihama* during February 2004-January 2005

illustration it is clear that *S. sihama* has a protracted breeding season which lasts from June to December with peaks of spawning activity are shown during September-November.

The monthly Gonado-Somatic Index (GSI) GSI \pm SD of male and female are given in Fig. 4. The peak value of GSI coincided with peak spawning period thus showing a close relationship between the

two (ovarian maturation stage, oocyte diameter and GSI value, all used as reproductive or maturation indices are interrelated).

The data on sex ratio is depicted in Table 1 & 2. A Chi-square test was performed on the data which showed that the proportions of males to females differ significantly only in September and November 2004 which happens to be the peak spawning season ($\chi^2 = 7.49$, $\rho < 0.01$; $\chi^2 = 11.58$, $\rho < 0.001$), respectively. However, the overall ratio of males to females was found to be very close to 1: 1.13, ($\chi^2 = 3.79$, $\rho < 0.05$) which suggest that both sexes were equally represented in the population of Goa estuaries.

The total number of mature eggs varied from 11,376 to 103,695 in individuals of 150 mm and 342 mm, respectively with mean value $42,575 \pm 4,730$. Linear relationships were found between fecundity and total length, weight of fish, and ovary weight (Fig. 5).

Discussion

The fish *S. sihama* spawns more than once in a single spawning season as revealed from the presence of matured eggs in the ovary. Our observations corroborate and supports the observations made by earlier workers^{4,6-7}. There are many advantages of multiple spawning in teleostean. It increases the total number of eggs produced in a single spawning season, spreads the risk of eggs and larval predation over a long period. At the same time, it acts to buffer any short-term adverse fluctuation in the abundance of suitable planktonic larval food⁸.

In the present study, it could be conveniently stated that 155-164 mm size group is the size at which both the sexes attain sexual maturity when they are ≥ 2 years old. The size at first maturity in *S. sihama* reported by others is 140-145 mm⁹. These variations could be the effect of geographical variations⁹.

Although, the ratio of males to females of *S. sihama* indicated the dominance of females over males in most of the months throughout the year (February 2004-January 2005), the Chi-square values were significant only in September and November 2004 and January 2005. During November and January, the GSI was higher in female that may indicate higher spawning activity of female at the time of sampling leading to aggregation of females in the spawning ground. Whereas, in September the dominance of males may be related to predominance of maturing males of a particular size having

Table 1—Sex ratio of *Sillago sihama* during February 2004-January 2005

Month	Total No.	No. of M	No. of F	Ratio M:F	X ²
F	77	38	39	0.97 : 1	0.01
M	98	46	51	0.90 : 1	0.27
A	111	51	60	0.85 : 1	0.73
M	101	49	52	0.94 : 1	0.09
J	82	38	44	0.86 : 1	0.44
J	112	56	56	1.00 : 1	0.00
A	99	49	50	0.98 : 1	0.01
S	77	50	26	1.92 : 1	7.49**
O	50	23	27	0.80 : 1	0.32
N	83	26	57	0.46 : 1	11.58***
D	84	43	41	1.00 : 1	0.05
J	106	38	68	0.56 : 1	8.49**

** $P < 0.01$, *** $P < 0.001$ Critical value X^2 3.84, 0.05, 1df

Table 2—Sex ratio of *Sillago sihama* in various size groups

Size class	Total No.	No. of M	No. of F	Ratio M:F	X ²
85-94	3	1	2	0.5 : 1	0.33
95-104	44	27	17	1.59 : 1	2.27
105-114	183	76	107	0.71 : 1	5.25*
115-124	242	132	110	1.20 : 1	2.00
125-134	336	178	158	1.13 : 1	1.19
135-144	203	80	123	0.65 : 1	9.11**
145-154	153	57	96	0.59 : 1	9.94**
155-164	135	54	81	0.67 : 1	5.40*
165-174	70	22	48	0.46 : 1	9.66**
175-184	25	10	15	0.67 : 1	1.00
185-194	12	4	8	0.50 : 1	1.33
195-204	6	2	4	0.50 : 1	0.67
205-214	8	3	5	0.60 : 1	0.50
215-224	5	2	3	0.67 : 1	0.20
225-234			3		

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$ Critical value X^2 3.84, 0.05, 1 df

significant Chi-square values during this month. However, the overall ratio suggested equality of males and females proportions in the population.

There is a large variation in the estimated value of fecundity reported by different workers in *S. sihama*. Palekar and Bal¹⁰ reported fecundity in the range of 16682 to 166130 while Reddy¹¹ stated that a fully mature ovary of *S. sihama* produce 14000 eggs. The values given by others are in the range of 6956-48,373⁴, 31,678-288,000⁹ eggs respectively. Many factors are responsible for such large variations in fecundity data. These are fertility, the frequency of spawning, parental care, egg size, population density

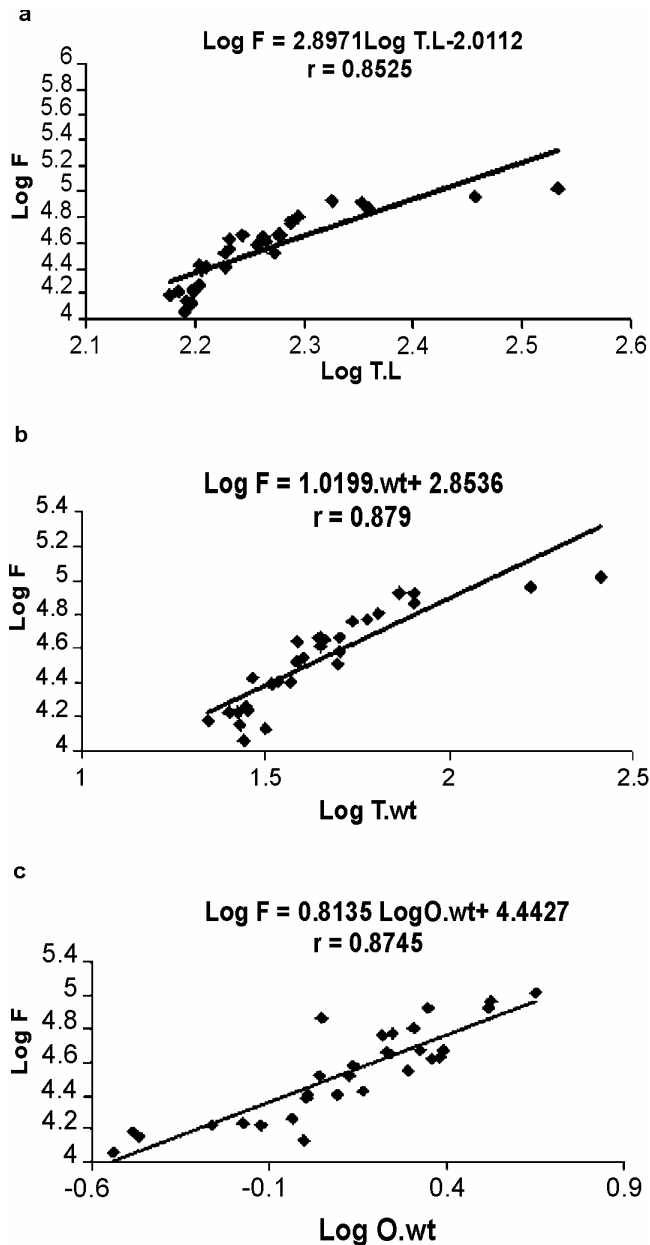


Fig. 5—Relationship of fecundity of *Sillago sihama* with (a) total length; (b) total weight and (c) ovary weight

and most importantly environmental factors such as temperature, salinity and availability of food¹. These factors directly or indirectly act on growth, metabolism and well-being of the fish.

Conclusion

In conclusion, it is stated that *S. sihama* spawns more than once in a single spawning season

producing large number of eggs as an adaptation to the extreme environment. Like most of estuarine fishes, the spawning period commences with the beginning of the monsoon season (June) and extending until December.

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