

Reproductive biology and fishery of the white sardine, *Escualosa thoracata* (Valenciennes, 1847) from the Ratnagiri coast, Maharashtra

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In the present study of this fish, it has indicated prolonged spawning season from October to April with peak spawning from November to February along the coast of Ratnagiri, Maharashtra. Highest GSI value for both sexes were observed during November (9.1487 for males and 5.4335 for females) and lowest during June (1.2772 for males and 0.8855 for females). The highest value of K was found in February for both sexes, male (2.06) and (1.86) in females. Overall male: female ratio was 1: 1.19 indicating slight dominance of females. The ova diameter for this species ranged from 0.02 to 0.64 mm, absolute fecundity ranged from 6156 to 9924 ova with an average of 7674 ova. Size at first maturity for females has been estimated to be 79 mm.

[Keywords: *Escualosa thoracata*, White sardine, Spawning, Fecundity, Drift gill net]

Introduction

The white sardine, *E. thoracata* (Valenciennes, 1847) is a shoaling Clupeid, inhabiting shallow coastal waters of India. Though landed in less quantity it is reported to occur from most of the coastal waters of the country. It supports economically important fishery along the southwest coast of India¹ but it also occurs in swarms on the east coast suggesting probable existence of an unexploited stock there². The fisheries of *E. thoracata* have assumed importance in recent years due to its huge demand from the domestic consumers. The highly discontinuous distribution of this fishery, present level commercial exploitation and the importance gained by it compared with oil sardine has developed enthusiasm to study its aspects in details, with respect to the fishery and biology along the Ratnagiri coast. Present study was conducted to investigate the reproductive biology of white sardine (*E. thoracata*) along the Ratnagiri coast of Maharashtra.

Materials and Methods

The white sardine fish has its restrictions of availability only along Harnai-Dabhol coast of Ratnagiri. Locally this fish is called 'Bhiljee' due to its silvery-white shiny appearance. Nearly 60-70 small boats conduct fishing in the near shore areas at a depth of 8-10 m using special small meshed (20-22 mm mesh size) drift gill net locally called Bhushi or

Bhiljee jaal. Length of the net ranges from 45-60 m with a height of 2 m. Each boat has a crew of four-five. Fishing operations are done during early morning around 4.00 AM and the set net is hauled after 2 hours. Mostly the catch consists only of white sardine fish and the landed fish ranges from 69-110 mm in total length. Catch depends upon the season, wind direction and tide patterns. On an average 30-40 kg catch is landed by each boat, which is marketed locally and to Goa and Mangalore.

The samples were collected twice in a month from the Burondi (Lat 17°68'33''N and Long 73°14'38''E) fish landing centre a minor fishing harbour situated in the north west coast of Ratnagiri from February 2015 to January 2016. A total 503 fish specimens, comprising of 275 males and 228 females were examined for reproductive studies. Total length TL (cm) and total weight (g) of fish were also recorded. For GSI estimation gonads were separated and subsequently weighed by electrical micro-balance with precision of 0.01g. GSI was estimated month-wise and sex-wise as per Bal and Rao³

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

Index of wellbeing or condition of fish was measured by the unit called Condition Factor "K" calculated for month-wise and sex-wise by using Fulton type condition factor of the form⁴.

$$K = W \times 10^5 / L^3$$

Where, K = condition factor,

W = weight of fish and L = total length

Condition factor has a correlation with the attainment of maturity, feeding intensity and the spawning behaviour as per Le Cren⁵

The fish were dissected and visual observation of testes and ovaries were done for observing maturity and spawning stage. Maturity stages of males and females were identified based on microscopic characteristics of testes and ovaries respectively. The observations were based on fresh gonads and the male and female maturity stages were classified as per James *et al*⁶. The occurrence of number of males and females in the sampled catch was recorded for one year and sex ratio was studied with respect to months and size groups. To ascertain the homogeneity of distribution of sex ratio were tested, chi-square test was applied⁷. $\chi^2 = (O - E)^2 / E$ in the usual notation.

For determination of length at first sexual maturity (Lm) of *E. thoracata* a total of 287 females were sampled. Fishes were grouped into 5 mm size groups and maturity stages V and VI were considered as mature. Using the fraction of mature fish at various size groups, the logistic function as fitted using the equation⁸.

$$P = 1 / (1 + \exp(-r(L - Lm)))$$

Where,

P = proportion of mature fish in length class L

r = the width of the maturity curve

Lm = length at 50% population attained maturity

For estimation of fecundity 30 fresh mature ovaries were used. A sub sample of 0.1 mg weighed each from anterior, middle and posterior region of each mature ovary with an electronic balance of 0.01 mg accuracy. The subsamples were then taken on counting slide with a few drop of water and the numbers of mature ova in the subsamples were counted for determination of fecundity as per Sinha⁹.

Fecundity = (Total weight of ovary / Sub-sample weight) × Number of ova counted in the subsample

Relative fecundity (number of eggs / unit body weight) was obtained by dividing absolute fecundity with total weight of fish. The relation of fecundity 'F' with total length 'TL', total weight 'TW' and ovary weight 'OW' was established by formula¹⁰.

$$F = a TL^b ; F = a TW^b ; F = a OW^b$$

Where, a and b = are constants.

F = fecundity

TL = is total length in mm.

TW = is body weight in gm.

OW = is ovary weight in gm.

The least square method was used to determine the correlation coefficient between fecundity and total length and body weight.

Ova diameter of intra ovarian eggs was measured from small portion of preserved ovaries taken from the anterior, middle and posterior region. The development of ova from one stage of maturity to another was studied using ocular micro meter. The measured ova diameters were grouped into 0.02 mm division class intervals and their frequency polygons were drawn for all stages of maturity.

Results and Discussion

In the present investigation GSI values observed for females were highest during the month of November (5.4335), December (4.6121), January (4.3218), February (4.8536), October (3.977) and March (3.6171) indicating the ripe stages. Higher GSI value for males observed was 9.1487 in the month of February, whereas lowest GSI value observed was 1.2772 in the month of June (Table 1).

In present study, higher GSI values were observed for males compared to females which is in contrast with generalization mentioned by Henderson *et al*¹¹. The possible reason could be the prolonged reproductive period with considerable amount of Length-wise GSI value was observed highest in 100-109 mm size group for both the sexes (Fig. 1).

Highest length-wise GSI value revealed highest value in 100-109 mm size group for both the sexes along Mumbai coast¹². The month-wise GSI value was highest in March for both sexes (male 9.15 and female 5.05) while the lowest value of GSI observed in the month of October for both sexes (male 3.17 and female 2.45) along Goa coast¹³.

Table 1 — Month-wise Gonado-somatic index of *E. thoracata*

Months	No. of Males	No. of Females	GSI Male	GSI Female
February	23	27	8.4278	4.8536
March	16	34	6.9759	3.6171
April	23	27	5.1793	3.313
May	27	23	1.2801	0.8941
June	13	12	1.2772	0.8855
August	19	31	1.4223	0.9914
September	21	29	2.3714	2.0365
October	26	24	6.0739	3.977
November	24	26	9.1487	5.4335
December	25	25	8.9606	4.6121
January	24	29	7.0382	4.3218

Highest K value was found in the month of November for both the sexes (1.86 female and 2.06 male) and lowest K value was found in month of May for both sexes (0.85 female and 0.91 male) is presented in (Fig.2). The highest GSI value was also observed during this period showing positive correlation between the conditions of fish. Highest value of K was found in month of November for females and in month of December for males while the lowest K value was obtained in August for both the sexes along Mumbai coast¹². Higher value of K was found in month of February for both the sexes (1.54 female and 1.39 male), while lowest K value was obtained in November for both the sexes (1.35 female and 1.24 male) along Goa coast¹³. Overall male: female sex-ratio was 1: 1.19 indicating slight dominance of females which was statistically significant. Chi-square test showed no significant

difference ($P > 0.05$) from the theoretical ratio of 1: 1 showing the equal proportion of males and females in most of the months. While significant difference ($P < 0.05$) was found in the sex ratio (male: female, 1: 2.13) only during the month of March (Table 2). In the commercial catches along Mangalore coast with overall sex ratio of (M: F, 1.13: 1) showed no significant difference¹⁴. Females were slightly dominant during entire period of investigations (0.83: 1, M: F) from Mumbai coast¹⁵. The dominance of females in all the months except November, January, February and April where ratio was 1: 0.9, while in March, significant dominance of females was observed (male: female, 1: 2.6)¹². These findings are in similarity with the present studies. The sex ratio along Goa coast varied from, 1: 0.81 to 1: 1.18 during the months of November and March respectively and overall sex ratio was 1: 0.93 indicating an apparent slight dominance of males, but was found to have no significant difference¹³. Present study conforms to these reports indicating slight dominance of females from Ratnagiri coast.

In the present study, 287 ovaries have been examined. Maturity stage I (Immature) was observed prominent during the months of April, May, June and August. The maturity stage II (early maturing) was observed during the months of April, May, June, August and September. Stage III (late maturing) was observed during months of May to December. Stage IV (early mature) ova were recorded throughout the year except in the month of March, April and May. Stages V (late mature) was observed throughout the year except in the month of May and June. Stage VI (ripe) was observed throughout the year except in the months of May to September. While stage VII (Spent) were observed in the month of October, November, December, January, February, March and April (Fig. 3).

The present study indicated that *E. thoracata* has prolonged spawning season from October to April with peak spawning during November to February. Spawning season of *E. thoracata* has been reported from November to February along the west coast¹⁶. The spawning season on west coast was from November to January¹ while the fish spawns twice a year between December to April with peak spawning during February and March from Mangalore waters¹⁴. The spawning season of white sardine was during October to February in Mumbai waters¹⁵. Higher percentage of spent fishes were found during

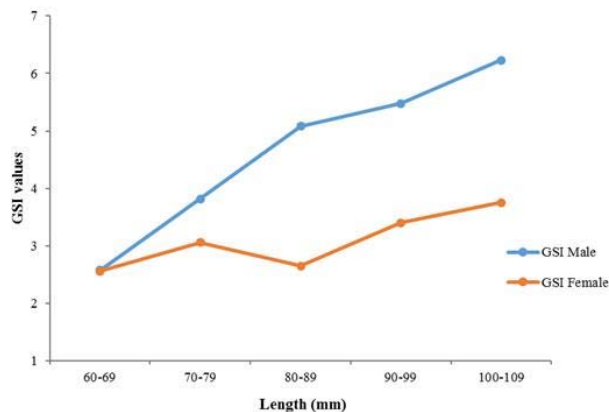


Fig. 1 — Length-wise Gonado-somatic index in *E. thoracata*

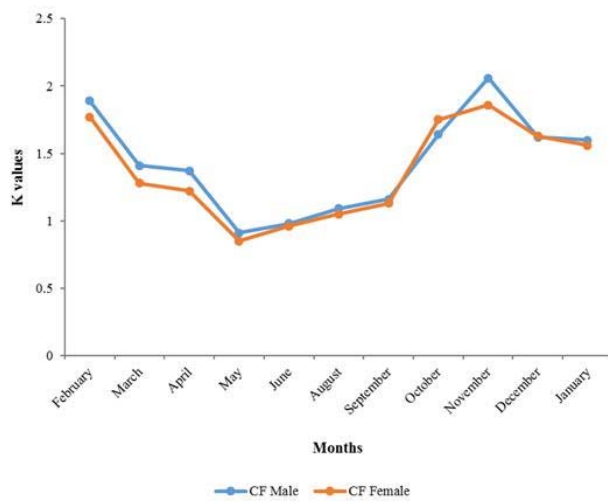


Fig. 2 — Month-wise condition factor in *E. thoracata*

Table 2 — Month-wise sex ratio of *E. thoracata*

Months	Total	Males	Females	Sex ratio (M:F)	Chi square value	Significance at 5% level	D.F
February	50	23	27	1:1.17	0.32	NS	1
March	50	16	34	1:2.13	6.48	S	1
April	50	23	27	1:1.17	0.32	NS	1
May	50	27	23	1:0.85	0.32	NS	1
June	25	13	12	1:0.92	0.04	NS	1
August	50	19	31	1:1.63	2.88	NS	1
September	50	21	29	1:1.38	1.28	NS	1
October	50	26	24	1:0.92	0.08	NS	1
November	50	24	26	1:1.08	0.08	NS	1
December	50	25	25	1:1	0	NS	1
January	53	24	29	1:1.21	0.47	NS	1
Total	528	241	287	1:1.19	4.01	S	1

S = Significant at 5% level, NS = Not Significant at 5% level, Table Value = 3.841

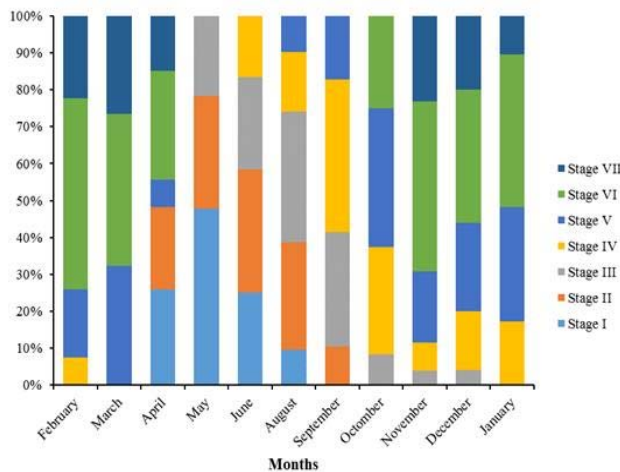


Fig. 3 — Month-wise percentage distribution of maturity stages in *E. thoracata* (Females)

September, October and February along with higher number of spawning individuals indicated the occurrence of mass spawning during this period along Mumbai coast¹². The spawning season reported was from February to April with peak spawning during the months from February to March from Goa waters¹³. Fishes were grouped into 5 mm size group's individuals wherein maturity stages V and VI were considered mature. Data has been presented in Fig. 4.

Present study indicated that the length at first maturity in *E. thoracata* has been estimated to be 79 mm. According to Devanesan and John¹⁶ length at first maturity of white sardine was 90 mm, Chidambaram and Venkataraman¹⁷ reported this to be 80 mm while Shivaprakasha and Joseph¹⁴ reported this to be 90 mm. The length at first maturity was

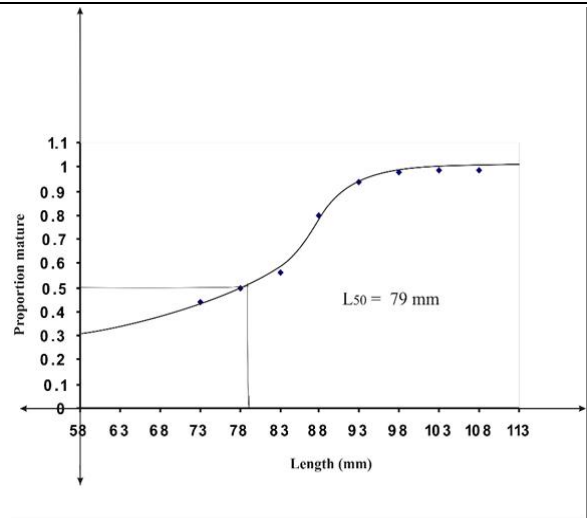


Fig. 4 — Length at first maturity of *E. thoracata* along Ratnagiri coast

reported to be 82 mm by Raje *et al.*¹⁵, 77.9 mm by Rahangdale¹² and 94.4 mm by Prajapat¹³ the former two are from Mumbai coast and the latter from Goa.

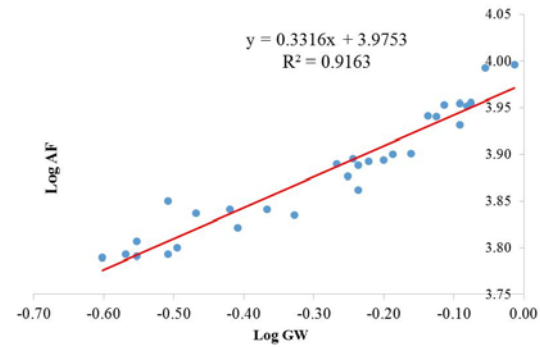
The absolute fecundity of *E. thoracata* ranged from 6156 to 9924 ova and average absolute fecundity was 7674 whereas, the relative fecundity ranged from 637 to 1034 ova per gram of body weight and average relative fecundity was 821 ova per gram body weight (Table 3). The absolute fecundity values were plotted against the respective gonad weight (GW), gonad length (GL), body weight (W) and total length (L) as a scatter diagram (Fig. 5). Fecundity (F) has shown positive relationship with GW, GL, W and L. Logarithmic relationship between F and GW is expressed by formula as $\text{Log } F = 3.9753 + 0.3316 \text{ Log } \text{GW}$ ($r^2 = 0.9163$); the logarithmic relationship between F and GL is expressed by formula as $\text{Log } F = 3.4987 + 0.7308 \text{ Log } \text{GL}$

Table 3 — Absolute and Relative fecundity of *E. thoracata*

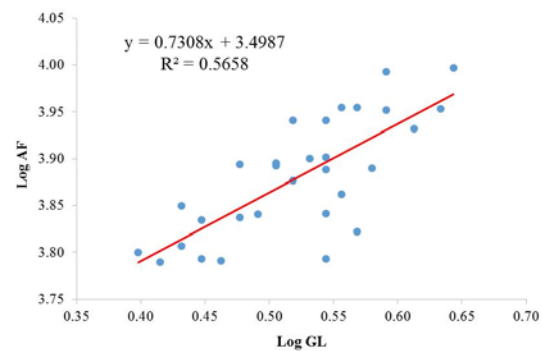
S. No	TL (cm)	BW (g)	GW (g)	GL (cm)	AF	RF (per g of BW)
1	9	8.1	0.58	3.5	7732	955
2	9.2	6.77	0.27	3.5	6214	918
3	9.9	9	0.39	3.7	6634	737
4	10.1	10.67	0.58	3.6	7276	682
5	10.5	13.12	0.81	4.1	8543	651
6	10.2	11.05	0.97	4.4	9924	898
7	9.8	9.8	0.47	2.8	6835	697
8	9.5	9.32	0.31	2.8	6208	666
9	9.4	9.39	0.28	2.9	6184	659
10	9.7	10.29	0.65	3.4	7946	772
11	10.2	11.01	0.75	3.5	8722	792
12	10.4	11.87	0.81	3.7	9014	759
13	9.1	7.41	0.38	3.5	6938	936
14	9.2	6.76	0.32	2.5	6311	934
15	9.3	8.37	0.34	3	6873	821
16	8.8	6.43	0.25	2.6	6156	957
17	9.5	8.51	0.31	2.7	7078	832
18	10.5	9.75	0.57	3.2	7863	806
19	8.5	6.2	0.28	2.7	6412	1034
20	9.1	7.32	0.43	3.1	6931	947
21	9.6	8.83	0.56	3.3	7532	853
22	10.2	9.86	0.73	3.3	8735	886
23	10.8	10.43	0.88	3.9	9833	943
24	10	10.26	0.83	3.9	8957	873
25	9.5	9.14	0.69	3.5	7968	872
26	10.9	12.29	0.63	3	7829	637
27	9.8	9.55	0.6	3.2	7810	818
28	10.4	11.69	0.84	3.6	9017	771
29	10.1	10.67	0.77	4.3	8976	841
30	10.7	11.45	0.54	3.8	7758	678
Average					7674	821

($r^2 = 0.5658$); logarithmic relationship between F and W is expressed by formula as $\text{Log F} = 3.3683 + 0.5281 \text{ Log W}$ ($r^2 = 0.5262$) and logarithmic relationship between F and L is expressed by formula as $\text{Log F} = 2.2682 + 1.6283 \text{ Log L}$ ($r^2 = 0.5164$). The number of eggs in mature female were about 8000¹. Absolute fecundity was 4163 to 10871 and mean absolute fecundity was 7259 per female¹⁴. The absolute fecundity was 6057 to 9980 and mean absolute fecundity observed was 7295 per female while relative fecundity was 833 to 1239 eggs per gram of body weight and fecundity has shown better relationship with ovary weight followed

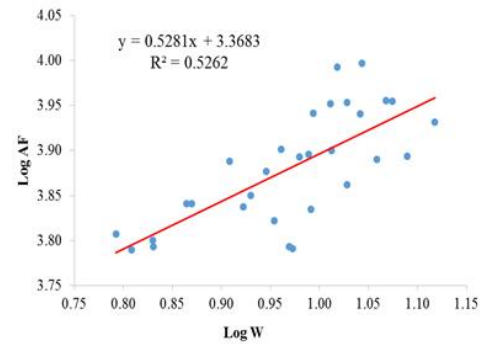
by fish weight¹². Absolute fecundity varied from 6505 to 8554 ova and average absolute fecundity was 7273 while the relative fecundity ranged from 512 to 1276 ova per gram body weight and average relative



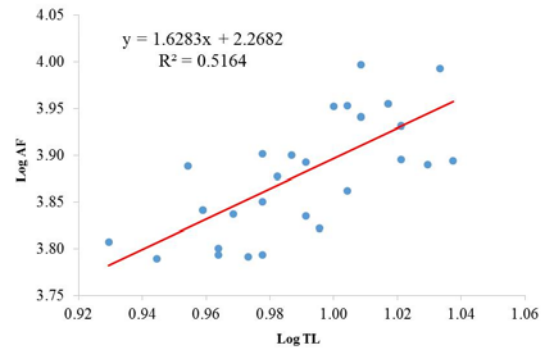
(a)



(b)



(c)



(d)

Fig. 5 — Logarithmic relationship (a) between F and GW (b) between F and GL (c) between F and W and (d) between F and TL in *E. thoracata*

fecundity was 717 ova per gram body weight and fecundity has shown positive correlation with length,

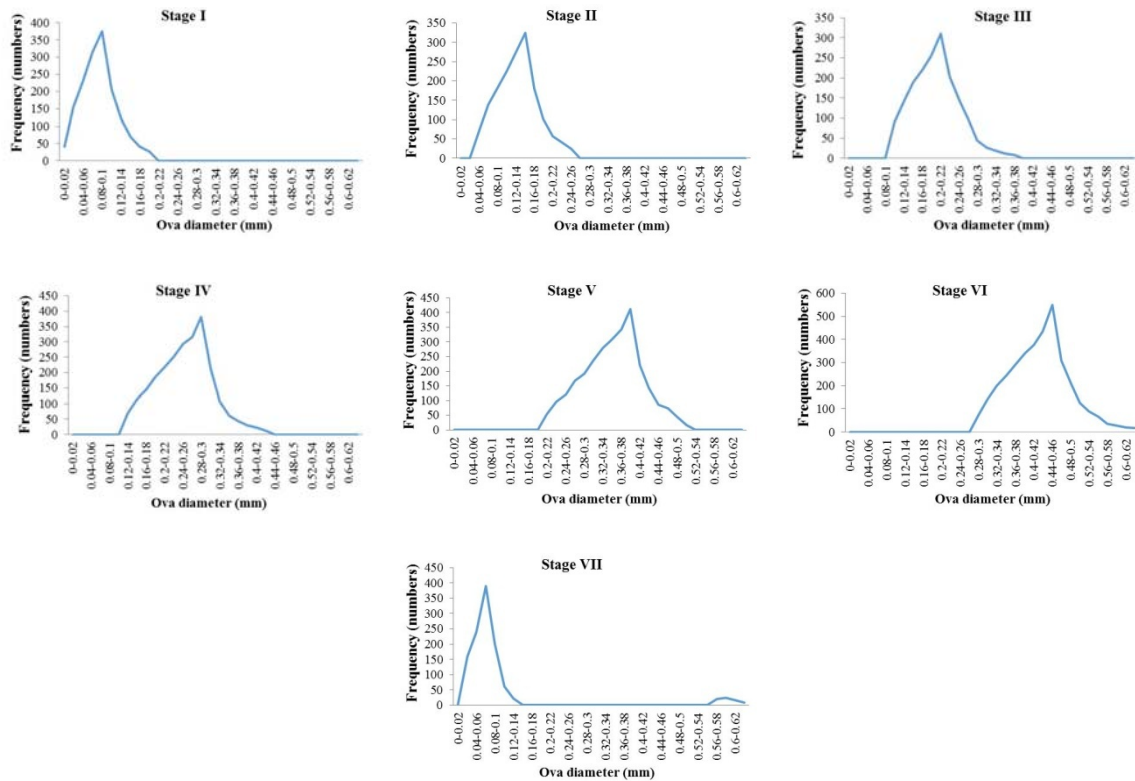


Fig. 6 — Ova diameter frequency in different maturity stages in *E. thoracata*

weight, gonad weight and gonad length of the fish¹³. Earlier and present investigation for fecundity estimates of this species reveals similar results and indicates a positive correlation between fecundity and length, weight, gonad weight and gonad length of the fish.

The ova diameter frequency polygons in ovaries of successive maturity stages are given in Fig. 6. Stage I, showing ova diameter range from 0.02 to 0.20 mm with a mode at 0.09 mm, stage II, ova diameter range from 0.04 to 0.26 mm with a mode at 0.15 mm, stage III, ova diameter up to 0.38 mm with mode at 0.21 mm, stage IV, ova diameter to about 0.44 mm with mode at 0.29 mm, stage V, ova diameter reaching up to 0.50 mm with mode at 0.39 mm, stage VI, ova diameter ranging from 0.28 to 0.64 mm with a mode at 0.45 mm and last stage VII ovary shrunken, reduced in size, hollow, sack like, small immature eggs present along with a few large denatured ova up to 0.64 mm with mode at 0.07 mm. In the present study, only one peak has been found indicating fish spawns once in a spawning period but the spawning period is prolonged. Similarly one peak was observed along Goa coast indicating that fish spawns once in a spawning period¹³. Observation on frequency distribution of ova belonging to the seven maturity

stages with two distinct peaks indicating spawning twice in a year has been reported from Mangalore coast¹⁴. Similar two distinct peaks following each other in reproductively active stages indicating the occurrence of two spawning during one breeding season has been reported from Mumbai coast¹².

Conclusion

E. thoracata supports an important commercial fishery along Ratnagiri coast of Maharashtra. Its catch depends upon the season, wind direction and tide. In the present study, landed catch caught by drift gill net which ranged from 69 mm to 110 mm with slight dominance of female catch throughout the year. Length at first maturity in *E. thoracata* has been estimated to be 79 mm and has prolonged spawning season with peak during November to February. It showed a positive correlation between condition factor and GSI, whereas fecundity showed a positive relationship with GW, GL, W and L throughout the year.

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