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REPRODUCTIVE BIOLOGY OF MULLET, *VALAMUGIL BUCHANANI* FROM MULKY ESTUARY OFF ARABIAN SEA, DAKSHINA KANNADA, INDIA

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ABSTRACT

The present investigation was carried out on reproductive biology of commercially important mullet (*Valamugil buchanani*) from the Mulky estuary of Dakshina Kannada coast during the period November, 2008 to October, 2009.The species spawned only once a year over a prolonged period extending from August to January with a peak in November to December. The female attained first maturity at 177 cm while the male at 181 cm. Male always recorded lower values of Gonado – Somatic Index (G.S.I.) and is significantly (P< 0.5) different from that of female owing to the greater ovary weight. The G.S.I. values were high during August to January with peaks in November to December implying prolonged spawning. Overall predominance of female in the population was noticed with the sex ratio of female to male was 1: 0.65.

Key words: Dakshina Kannada, Mullet, Reproductive biology, *Valamugil buchanani*.

INTRODUCTION

Fishes of the Mugilidae represent one of the major commercial resources of tropical and warm-temperate estuaries (McDowall, 1988; Blaber, 1997), and their ecological function in food webs is of the greatest importance (Laffaille *et al.*, 1998; Cardona *et al.*, 2001). In the past, mugilids were the most abundant species in almost all the estuaries along the Indian coast and hence formed a very important species for the local fishery. Unfortunately, after extensive land reclamation of lagoons and brackish water lakes together with the constant pollution from agriculture and upstream industries and high fishing pressure, the status of mugilids is now fragile. At least one species,flathead grey mullet, *Mugil cephalus* L. 1758, is becoming endangered and rare (Glamuzinaand Bartulovic, 2010).

Conservation and management measures require information on the fundamental biology of mugilids and their habitat. Over recent years, there has been an increased need to estimate the reproductive population variables of marine fishes in order to obtain accurate estimates of the effect of fishing on the reproductive potential ofthe stock (Murawski *et al.*, 2001). An increase in understanding the reproductive biology of mugilids is essential to determine the parameters to be used in age-structured models of stock assessments. Moreover, knowledge of spawning season and fishing location are instrumental in establishing time and area closures to protectessential fish habitats along with modification of fishing gear to enhance the survival of heavily exploited species (Rosenberg *et al.*, 2000). All grey mullet are abundant in estuaries and inshore waters, where they spend most of their life, but they spawn in marine waters (McDowall, 1988). The reproductive cycle of a few grey mullet species in some of the estuaries and lagoons has been analysed (Brusle,1981; Hotos *et al.*, 2000).However, such data are completely lacking for the mugilids from the West coast of India. Further, the studies on spawning season and spawning areas of these fishes from Dakshina Kannada coast are Scanty.

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In accordance with the above, present study was designed to examine some of the aspects of reproductive biology of one of the commercially important mullet (*Valamugil buchanani*) of Dakshina Kannada, Karnataka coast.

MATERIALS AND METHODS

A total of 447*Valamugil buchanani* were collected fortnightly from Mulky fish market and Mulky estuary of size ranging from 12.5 – 23.5 cm total length (TL) and 20.26 – 116.07g of total body weight comprising 176 male and 271 female during the period of November, 2008 to October, 2009. The length, weight, sex and stage of maturity of individual fish and weight of each gonad in each sample were recorded. Fishes were gutted in order to remove and measure the gonad mass and preserved in 10% formalin for further analysis.

Maturity stages and growth of ova: Maturity stages of male and female were classified based on macroscopic appearance of the ovary and microscopic characteristics of testes and ova (Gowda, 1983) respectively. All specimens were sexed as male, female or immature based on macroscopic observation of the gonads where as the microscopic observations were based on 10% buffered formalin preserved material.Ova from anterior, middle and posterior portion of ovaries were observed under compound microscope fitted with ocular micrometer where ocular division had magnification of 0.01 mm to each ocular micrometer division for ova diameter studies. A total of 200 - 300 ova from each ovary were measured.

Spawning frequency and season: The frequency of spawning was estimated based on ova diameter distributions in advanced stages of ovaries following Hickling and Rutenberg (1936) and De Jong (1940).Spawning season was determined on the basis of availability of mature gonads in the commercial catches. The Gonado – Somatic Index (GSI) and relative condition factor (Kn) were also considered for assessing the spawning season.

Size at first maturity and GSI: The size at first maturity was determined by plotting cumulative percentage of mature fish - III, IV, V and VI stages in case of female and stage III and IV in male against length (James and Badrudeen, 1981; Udupa, 1986).The Gonado somatic Index (GSI) was calculated by following James (1967) and Baragi (1977). Ovaries were weighed to the nearest milligram while excess moisture from fish and gonads were removed using a blotting paper prior to weighing.

$$GSI = \frac{\text{Gonad weight X 100}}{\text{Total body weight}}$$

The average GSI values were plotted against months to find out the seasonal variation of the gonad weight and subsequently the spawning season.

Fecundity: Fecundity was estimated gravimetrically (Hunter and Macewicz, 1985) using formalin preserved ovaries of the stages IV and V weighing them to the nearest milligram. A small sample was weighed and counted to estimate the absolute fecundity.

$$\text{Fecundity} = \frac{\text{No.of mature ova in the sample}}{\text{Weight of the sample (g)}} \text{ X Total weight of the ovary}$$

Sex - ratio: Sex - ratio was studied with respect to months and size groups of fish and analyzed by χ^2 (Chi-square) test to find out dominance of sex by using the following formula.

$$\chi^2 = \frac{(OM-E)2}{E} + \frac{(OF-E)2}{E}$$

Where, O_M and O_F = observed number of male and female respectively.

E = Expected number of male or female in a month= n/2

RESULTS AND DISCUSSION

Development of ova to maturity: The six stages of maturity of typical ovaries and the ova diameter values are depicted in Table 1. In stage I the size of ova ranged from 0.02 – 0.06 mm with the mode at 0.02 mm which progressed to 0.06 mm in the stage II where the largest ova measured about 0.22 mm. In stage III the mode progressed yet again to 0.26 mm, the maximum size of ova being 0.3 mm. In the stage IV, the mode became 0.3 mm with a maximum size of 0.42 mm. In stage V, there were two groups of eggs. The immature group of egg was stationary at 0.06 mm whereas, the mature group progressed further to 0.46 mm and the maximum size of the ova was 0.58 mm. In the Stage VI the maximum size of the ova was found to be 0.34 mm with the mode at 0.18 mm.

Spawning frequency and spawning season: The spawning season has been determined on the basis of occurrence of individuals in mature and spawning

TABLE 1: Ova diameter (mm) at different maturity stages of *Valamugil buchanani*

Stage of maturity	Description of ova	Mode of largest group of ova	Maximum size of ova
I	Immature	0.02	0.1
II	Maturing	0.06	0.22
III	Early mature	0.26	0.30
IV	Late mature	0.3	0.42
V	Ripe	0.46	0.58
VI	Spent	0.18	0.34

stages in each month has been shown in Table 2.The immature ova are invariably present in all the stages of the ovaries.Two batches of mature groups of ova were observed.Ovary of stage I was predominant in almost all the months excluding the months October to January while the Stage II was dominant during the months of April to September. Stage III were found in abundance during the months of October to February, while the Stage IV was found more in number in the months of October, November, January and March. Stage V was highest during October to January and in smaller proportions in rest of the months and Stage VI did not occur in the months of February to August and very few in rest of the year.In the ovaries of stage IV and V, after the extrusion of the first group of mature ova, the second group gets mature, which makes spawning a continuous process.

As the advanced group of ova exhibit a wider size range, it is reasonable to conclude that the fish spawns for a longer duration. Similarly, the presence of different stages of gonads at a given time indicates that the species would spawn for a greater part of the year.Thus, in the present study, *Valamugil buchanani* was found to spawn only once a year but over a long period of time extending from August to January with a peak during November and December. This agreed with the observations of *L. macrolepis* (Luther, 1963). Extended spawning once a year has been reported in case of *Mugil parsia* (Sarojini, 1957), *L. macrolepis* and *M. cephalus* (Luther, 1963). Such extended spawning season was

TABLE 2: Month-wise occurrence (percentage) of Testes and Ovary of *Valamugil buchanani* in different stages of maturity

Month	Sex	No. of fish	Maturity stages					
			I	II	III	IV	V	VI
Nov. '08	M	12	8.33	16.67	16.67	33.33	16.67	8.33
	F	25	12.00	20.00	16.00	24.00	24.00	4.00
Dec.	M	13	7.69	30.77	23.08	15.38	15.38	7.69
	F	27	11.11	14.81	18.52	25.93	25.93	3.70
Jan. '09	M	11	9.09	18.18	27.27	18.18	18.18	9.09
	F	26	7.69	15.38	23.08	23.08	26.92	3.85
Feb.	M	16	31.25	18.75	31.25	12.50	6.25	0.00
	F	17	5.88	11.76	23.53	29.41	23.53	0.00
Mar.	M	13	38.46	15.38	15.38	23.08	7.69	0.00
	F	28	32.14	28.57	21.43	14.29	3.57	0.00
Apr.	M	17	47.06	52.94	0.00	0.00	0.00	0.00
	F	18	55.56	44.44	5.56	0.00	0.00	0.00
May	M	17	52.94	41.18	5.88	0.00	0.00	0.00
	F	31	48.39	41.94	9.68	0.00	0.00	0.00
June	M	20	55.00	40.00	5.00	0.00	0.00	0.00
	F	15	46.67	33.33	20.00	0.00	0.00	0.00
July	M	20	45.00	30.00	15.00	10.00	0.00	0.00
	F	22	45.45	36.36	13.64	4.55	0.00	0.00
Aug.	M	8	50.00	25.00	25.00	0.00	0.00	0.00
	F	27	48.15	33.33	7.41	7.41	3.70	0.00
Sep.	M	17	29.41	23.53	17.65	17.65	5.88	5.88
	F	19	36.84	26.32	15.79	10.53	5.26	5.26
Oct.	M	12	8.33	16.67	25.00	25.00	16.67	8.33
	F	16	31.25	25.00	18.75	12.50	6.25	6.25
Total	**M**	**176**	**34.09**	**28.98**	**15.91**	**11.93**	**6.25**	**2.84**
	F	**271**	**31.37**	**27.68**	**15.87**	**12.92**	**10.33**	**1.85**

also seen in *V. seheli* (Gowda, 1983), *L. tade* (Reddy, 1985), *V. speigleri* (Baburaj, 1987) and *V. seheli* (Moorthy, 2000) from the different estuaries of Dakshina Kannada.

Relationship between the size of the fish and maturity: Fishes were segregated sex-wise and grouped into 10 mm size groups and the details of per cent occurrence of fish in various maturity stages were calculated and presented in Table 3. Stages III, IV and V were considered to be mature in male, whereas stages III, IV, V and VI were considered for calculation of size at first maturityin female. Based on the percentage occurrence of mature fishes in various size groups, it was found that female attained maturity at a smaller size than male. The attainment of first maturity in female at 173 mm and male at 180 mm was noticed.

From the observation of individual data collected for each male, all themale up to 95 mm were in immature stage (Stage I) whereas in the size group of 80 – 100 mm, about 10.53 per cent fish were found to be mature which gradually increased to 49 per cent in the size group of 120 – 140 mm. More than 50 per cent of the fishes were found to be mature (61 %) in the size group of 140 – 160 mm. From this group onwards, mature fishes increased to reach 100 per cent at 200 – 220 mm size group. It can be concluded that the size at first maturity for male appears to be 140 - 160 mm size range whereas in female, all fishes were immature till 60 – 80 mm size group (Table 3), but 36 % of mature fishes were found in the size group of 100 – 120 mm, which increased up to 42 % in 140 – 160 mm size group. In the size group of 160 – 180 mm, most of the fishes were found to be matured (61 %). The percentage of mature fish gradually increased to 100% at 200 – 220 mm size group. Based on this, it can be concluded that in case of female, the size at first maturity appears to be in the size range of 160 – 180 mm.

Size at first maturity: In order to determine the length at which, the majority of fishes become mature, the cumulative percentage distribution of fishes (Stage II, III and IV in case of male and Stage

TABLE 3: Percentage occurrence of different stages of maturity of testes of *Valamugil buchanani*in relation to different size groups.

Size group(cm)	Sex	No. of fish	Maturity stages					
			I	II	III	IV	V	VI
12-13	M	6	66.67	33.33	0.00	0.00	0.00	0.00
	F	3	100.00	0.00	0.00	0.00	0.00	0.00
13-14	M	16	50.00	37.50	12.50	0.00	0.00	0.00
	F	9	77.78	22.22	0.00	0.00	0.00	0.00
14-15	M	37	45.95	43.24	10.81	0.00	0.00	0.00
	F	26	46.15	42.31	11.54	0.00	0.00	0.00
15-16	M	54	38.89	29.63	16.67	11.11	3.70	0.00
	F	100	37.00	34.00	12.00	14.00	3.00	0.00
16-17	M	27	29.63	37.04	22.22	11.11	0.00	0.00
	F	71	32.39	28.17	22.54	11.27	5.63	0.00
17-18	M	13	15.38	7.69	30.77	38.46	7.69	0.00
	F	30	10.00	26.67	23.33	13.33	20.00	6.67
18-19	M	7	0.00	0.00	42.86	28.57	14.29	14.29
	F	18	0.00	0.00	22.22	27.78	38.89	11.11
19-20	M	7	0.00	0.00	0.00	42.86	42.86	14.29
	F	11	0.00	0.00	9.09	27.27	54.55	9.09
20-21	M	4	0.00	0.00	0.00	50.00	25.00	25.00
	F	3	0.00	0.00	0.00	33.33	66.67	0.00
21-22	M	1	0.00	0.00	0.00	0.00	100.00	0.00
	F	0	0.00	0.00	0.00	0.00	0.00	0.00
22-23	M	3	0.00	0.00	0.00	0.00	66.67	33.33
	F	0	0.00	0.00	0.00	0.00	0.00	0.00
23-24	M	1	0.00	0.00	0.00	0.00	0.00	100.00
	F	0	0.00	0.00	0.00	0.00	0.00	0.00
Total	**M**	**176**	**34.09**	**28.98**	**15.91**	**11.93**	**6.25**	**2.84**
	F	**271**	**46.15**	**42.31**	**11.54**	**0.00**	**0.00**	**0.00**

III, IV and V in case of female) were taken into account. Cumulative percentage frequency was considered to indicate the overall reproductive maturity of the population as a whole. As per the method of Udupa, 1986, it was found that the male mature at 181 mm and female at 177 mm total length (Fig. 1). The size at first maturity was calculated among other methods from the relative condition factor also. The peak on a curve with a sudden decrease in the relative condition "K_n" with the increasing length is a good indication of length at which sexual maturity is attained (Hart, 1946). It was found that both the sexes attained maturity during 140 - 150 mm T.L.

Gonado – Somatic Index (G.S.I.): The gonado-somatic index (G.S.I) of *Valamugil buchanani* was recorded in different months to confirm the spawning period. Male and female were considered separately for estimation of the Gonado – Somatic Index (G.S.I.). The relative ovary weight was calculated for each individual and was arranged for each month and has been presented in Fig 2. The G.S.I. values for male ranged between 0.48 and 1.82. It was found that the gonado-somatic index were high during the months of August to January with a peak in November to January, indicating that this was the spawning period of *Valamugil buchanani* along the Mangalore coast. The average G.S.I. was observed

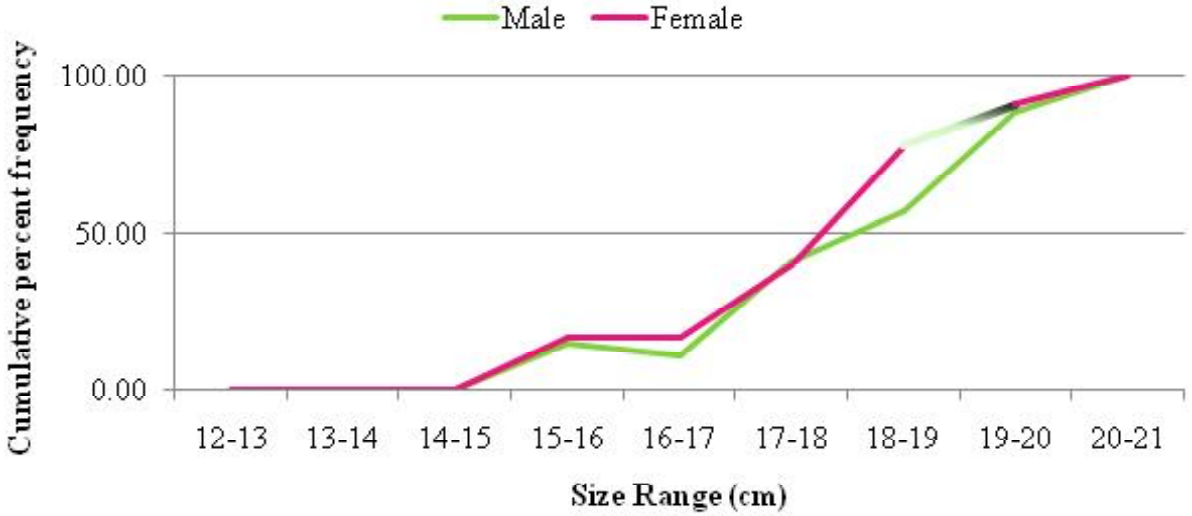

FIG 1: Cumulative percentage frequency of matured gonads of male and female

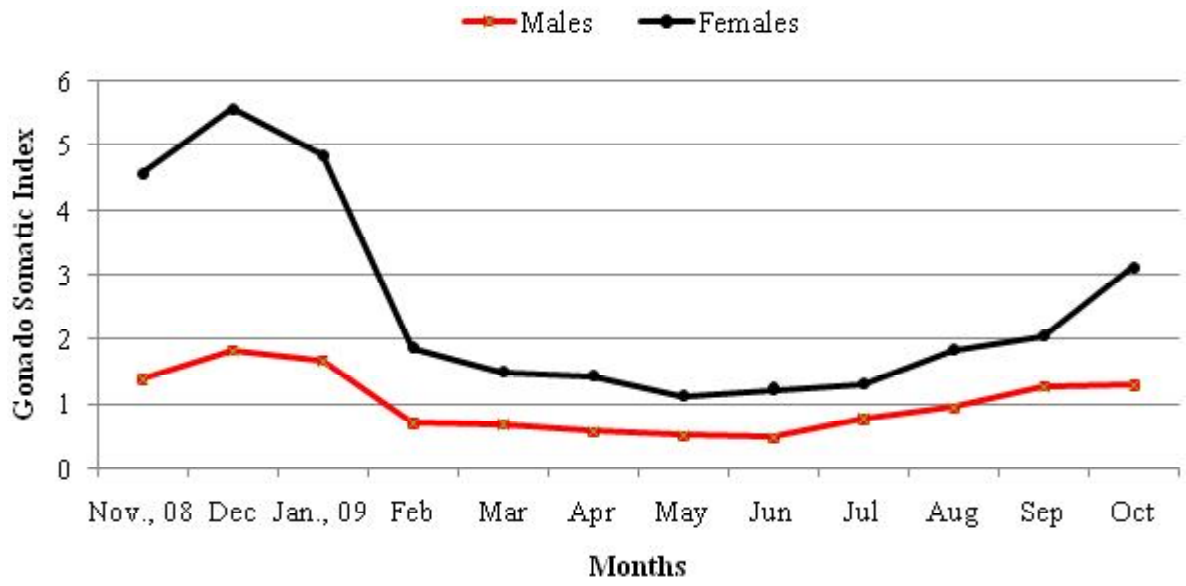

FIG 2: Seasonal variation in Gonado – Somatic Index

to be more in female than in male perhaps due to a greater ovary weight compared to testis. The G.S.I. values were higher during maturation of gonads.

Sex – ratio: A total of 447 individuals comprising 176 male and 271 female were examined for the study of sex – ratio both month wise (fig 3) and size wise (fig 4).Chi-square test was applied to ascertain any significant difference in number of male and female in the monthly samples. The chi-square values at 5% probability level showed that the observed proportion of male and female were statistically different in the months of November, December, January, March, May and August. Also the pooled sex ratio (1: 0.65) for male and female was significantly different at 5% probability level. The same was noticed in various size groups when tested with Chi square at 5% probability level. Chi-square test indicated a significant deviation from the theoretical ratio of 1: 1 showing the unequal proportion of male and female in most of the months. Sex-ratio studies also indicated that, males are dominant in all the size groups, except in the size ranges of 150-200 mm. Similarly, males were observed as dominant sex in other mugilid populations such as *Abtrihetta forsteri* (Thomson, 1957),*L. tade* (Reddy, 1985),*V. speigleri* (Baburaj, 1987),*M. auratus* (Kestevan, 1942) and*V. seheli* (Gowda, 1983 and Moorthy, 2000). This could be due to the different fishing methods used, spawning and feeding migration, schooling behaviour of the fish and differences in natural and fishing mortality between the sexes (El-Zarka and El-Sedfy, 1970).

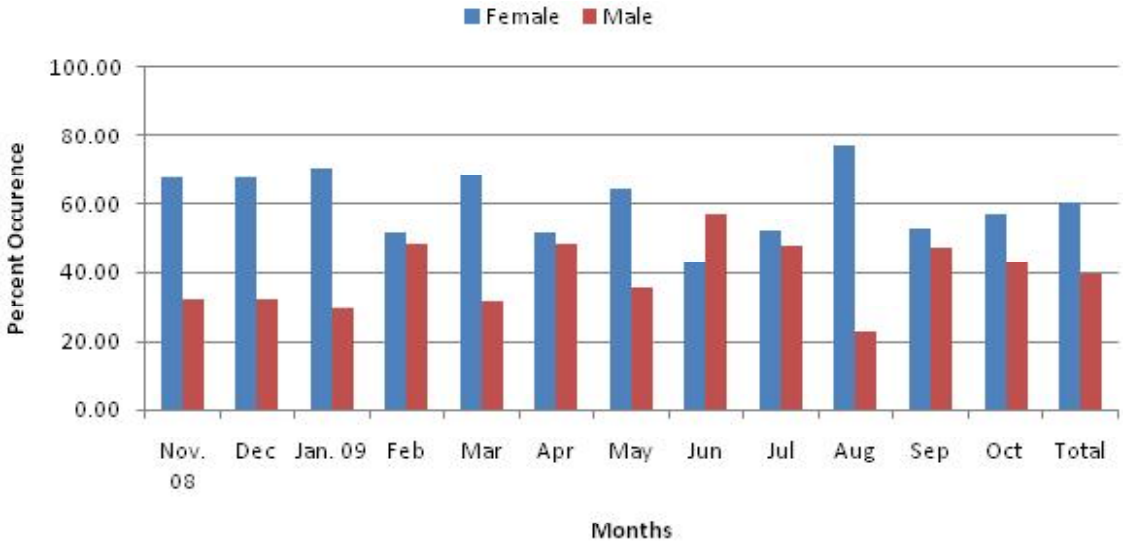

FIG 3: Seasonal variation in sex – ratio of *Valamugil buchanani*

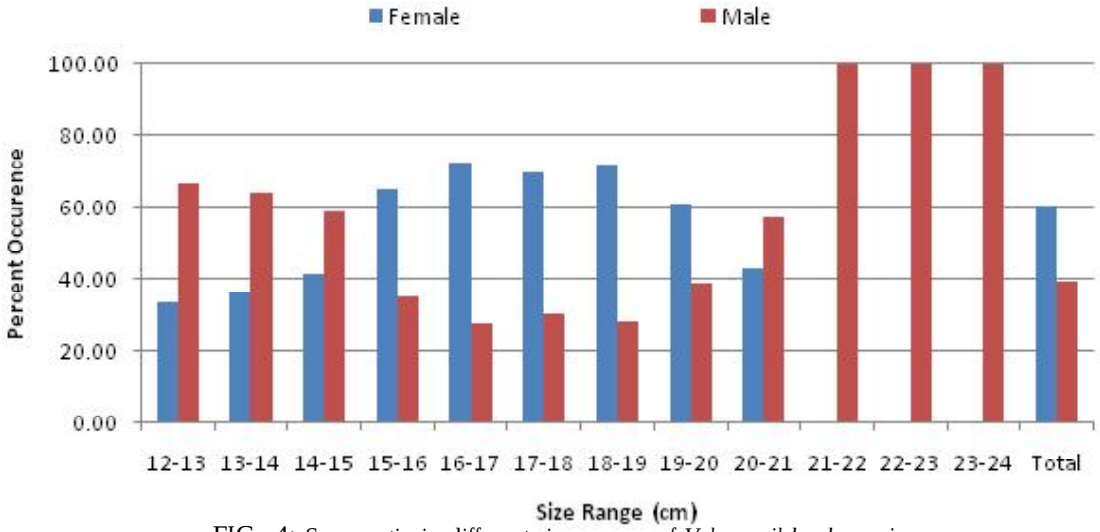

FIG 4: Sex – ratio in different size groups of *Valamugil buchanani*

Fecundity: Knowledge of total number of eggs produced by a fish during a year is important in determining the spawning potential of the fish. The estimates of fecundity ranged from 31,168 to 1,24,154 eggs with an average of 59,591 eggs per female depending upon the size of the fish (146 – 205 mm T.L.).Different species of mullets exhibit varying fecundities. The fecundity in *M. parsia* (Sarojini, 1957) and*V. speigleri* (Baburaj, 1987) varies from 2 to 6 lakhs and 1.34 to 8.39 lakhs respectively for different size of the fishes.

The minimum weight of the mature *V. buchanani* was 31.66gm with a maximum of97.32 g with length varying between 146 mm to 205 mm respectively. Generally the number of ova increased with increase in weight and length. The logarithmic relations between fecundity and length of fish, fecundity and weight of fish and fecundity and gonad weight were found to be linear indicating that the fecundity generally increased with increasing length, weight and ovary. Reddy (1985) and Baburaj (1987) observed a straight line logarithmic relationship between length of fish and fecundity, weight of the fish and fecundity and gonad weight of the fish and fecundity in *L. tade* and *V. speigeleri* respectively from Mangalore waters. In view of dwindling fish resources due to over- exploitation, the result of the present study on breeding seasonality, behaviour and the reproductive biology of the mullet,*Valamugil buchanani* could help the scientists, stake holders and the fisheries managers to take up appropriate management strategies to avoid recruitment over-fishing and growth over-fishing.

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