

## **Some aspects of reproductive biology of *Apogon quadrifasciatus* Cuvier, 1828 collected from the trawling grounds off Visakhapatnam, east coast of India**

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### **ABSTRACT**

*Sex ratio indicated that there was a significant difference between males and females in their occurrence. Males dominated the catches during the study period. A scale of six stages of maturity of gonads was identified. The length at first maturity was found to be 82 mm in females. Females in length range of 81 to 90 mm formed the spawning population. The GSI has been found to be high during February - April in females. Spawning takes place throughout the year with peak during February to April. Fecundity varied from 1808 to 19678.*

**Key words:** *Apogon quadrifasciatus*, Sex ratio, Spawning season, GSI, Fecundity, Visakhapatnam

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### **INTRODUCTION**

Visakhapatnam coastal waters on east coast of India support multi-species fishing and a wide variety of fishes represented in the by-catch. These fishes are of little demand in fresh condition but are widely used for the preparation of fish meal. The family Apogonidae includes approximately 200 species in about 24 genera which are mostly abundant in Indo-Pacific reefs [19]. These species are mostly demersal assemblages in many coastal areas and caught mainly as by-catch in bottom trawl fisheries [21 and 4]. *A. quadrifasciatus* (two striped cardinal) contributed about 7.91% of total fish by-catch landed at Visakhapatnam (22). Due to the paucity of information on reproductive biology of *A. quadrifasciatus* in this region, the present study aims to obtain information on sex ratio, maturity, length at first maturity (Lm), spawning season, development of ova and fecundity.

### **MATERIALS AND METHODS**

Present study was based on 496 specimens of *Apogon quadrifasciatus* (males:279; females:217) ranging in size from 44 mm to 99 mm and weight 1g to 15.51g collected from commercial trawl catches at Visakhapatnam fishing harbor (Plate 1) at ten days intervals during June 2006 to May 2007. The samples were not available during May due to fishing holidays from April 15<sup>th</sup> to May 31<sup>st</sup> which were implemented for conservational purpose. The collected samples were immediately brought to the laboratory for further analysis. After measuring the total length (nearest 1mm) and weight (nearest 0.5gm) for each specimen, the belly of the each fish was cut open to note the sex, color and general appearance of the gonads. The gonads were then carefully removed and preserved in 5% formalin in labeled bottles for further analysis. The sex of the sampled population was analyzed according to month and size. Maturity of the gonads was determined by external appearance like color, size, area occupied by them in the body cavity and microscopic observations of ova [11]. The mean length at first maturity (Lm) was determined for females by fitting a logistic curve [9]. To determine the length at first maturity, females were grouped into 10 mm length

intervals and the gonads of stage IV and V (mature and ripe) were considered for this study. The average length at which 50% of the population attains first maturity was considered as length at first maturity.

Percentage occurrence of matured fish (fishes with stage IV and V gonads) and Gonado Somatic Index of females were used to determine the spawning season [20]. The Gonado Somatic Index (GSI) was calculated using the formula:

$$\text{GSI} = \text{GW}/\text{TW} \times 100$$

Where, GW: Gonad weight (g); TW: Total body weight (g) and GSI: Gonado Somatic Index.

Measurement of ova diameter [3] was made by taking sections from middle of the ovary. All the ova were teased out on a micro slide and their diameters were measured under a compound microscope with the help of an ocular micrometer at 40x, where each micrometer division (md) is equal to 0.02mm. In early maturing, maturing, mature and ripe ovaries (stage II to V) about 500 – 600 ova were measured from each ovary. For convenience, the ova were divided into diameter groups of two micrometer divisions each (i.e. 1-2, 3-4, 5-6 and so on) to determine the frequency distribution of ova of different sizes towards maturity.

Estimation of fecundity [18] was made on intact ovaries of ripe stage collected during the study period. Relationship between fecundity (F) and fish length (L), weight (W) and ovary weight (OW) were estimated using linear regression equation [2] as  $F = aX^b$  where a = constant, b = exponent, F = fecundity, X = total length, body weight and ovary weight. Fecundity values were plotted against the respective total length, weight and ovary weight of fish.

## RESULTS

### Sex ratio

Trends in the ratio of males and females in different months during the study period from June, 2006 to May, 2007 have been shown in Table 1. Males dominated the catches during Jun 06, Jul 06 Sep 06, Dec 06, Feb 07 and Apr. 07. Females dominated in Aug 06, Oct 06, Nov 06 and again Jan 07 and Mar 07. The sex ratio for male to female during this period was 1:0.77.

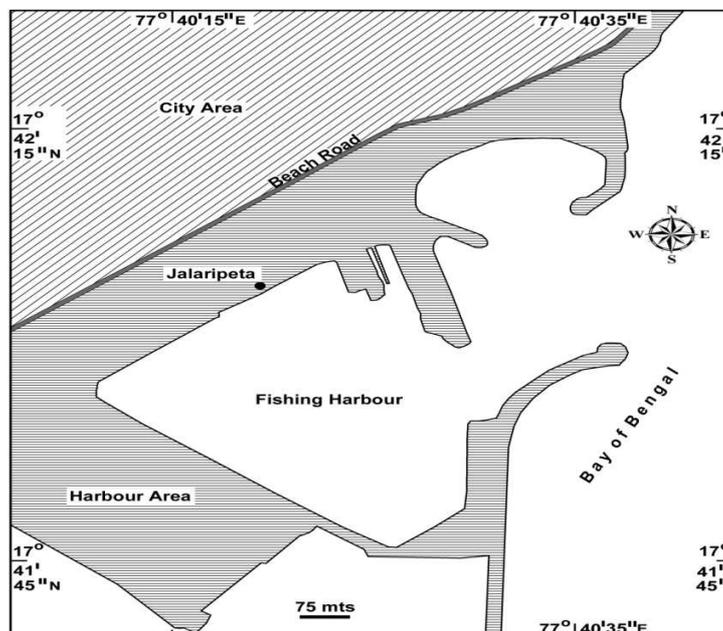


Plate 1: Map of the study area: Visakhapatnam Fishing Harbor, Bay of Bengal.  
\*Significant

Sex ratio showed marked trend from small size group to large size group (Table 2). Males dominated at 41 to 80 mm length groups while females dominated from 91 to 105 mm length groups. Chi square analysis indicated that there was a significant difference ( $p < 0.05$ ) between the sexes in their occurrence.

**Table 1: Month wise sex ratio of *A. quadrifasciatus***

Months	Total no. of specimens	Males	Females	Ratio of males:females	$\chi^2$ value	P value
Jun	49	37	12	1:0.32	12.7551	0.000355*
Jul	33	25	8	1:0.32	8.757576	0.003083*
Aug	30	7	23	1:3.28	8.533333	0.003487*
Sep	38	23	15	1:0.65	1.684211	0.194366
Oct	21	6	15	1:2.5	3.857143	0.049535*
Nov	27	8	19	1:2.37	4.481481	0.034264*
Dec	17	10	7	1:0.7	0.529412	0.466854
Jan	31	11	20	1:1.81	2.612903	0.105998
Feb	43	28	15	1:0.53	3.930233	0.047425*
Mar	86	41	45	1:1.09	0.186047	0.666228
Apr	121	83	38	1:0.45	16.73554	4.3E-05*
May	-	-	-	-	-	-
Total	496	279	217	1:0.77	7.75	0.005371*

**Table 2: Length wise sex ratio of *A. quadrifasciatus***

Length	Total no. of specimens	Males	Females	Ratio of males:females	$\chi^2$ value	P value
41-50	6	6	-	1:0	6.0000	0.014306*
51-60	50	47	3	1:0.06	-	4.89E-10*
61-70	83	63	20	1:0.31	22.27711	2.36E-06*
71-80	150	84	66	1:0.78	2.1600	0.141645
81-90	92	46	46	1:1	1.57E-18	1.0000
91-100	107	33	74	1:2.24	15.71028	7.38E-05*
101-110	8	-	8	0:1	8.0000	0.004678*
Total	496	279	217	1:0.77	7.7500	0.005371*

\*Significant

**Table 3: Month wise percentage frequency distribution of females in *A. quadrifasciatus* with different stages of maturation**

Months	Total Number	I	II	III	IV	V	Spent
Jun	12	8.33	25	33.33	16.67	16.67	-
Jul	8	-	25	25	50	-	-
Aug	23	8.69	13.05	21.74	21.74	4.35	30.43
Sep	15	13.33	6.67	26.67	40	-	13.33
Oct	15	13.33	-	33.34	13.33	13.33	26.67
Nov	19	-	21.05	26.32	31.58	15.79	5.26
Dec	7	-	14.28	85.72	-	-	-
Jan	20	30	5	30	10	5	20
Feb	15	13.33	20	6.67	-	20	40
Mar	45	2.22	13.34	20	28.89	11.11	24.44
Apr	38	13.16	18.42	10.53	10.53	21.05	26.31
May	-	-	-	-	-	-	-

**Table 4: Length wise percentage frequency distribution of females of *quadrifasciatus* with different stages of maturation**

Length	Total Number	I	II	III	IV	V	Spent
51-60	3	33.33	-	33.33	-	-	33.34
61-70	20	20	25	15	5	10	25
71-80	66	13.64	18.18	16.67	22.72	10.61	18.18
81-90	46	6.52	13.04	28.26	8.69	23.92	19.57
91-100	74	5.4	10.81	28.38	22.97	12.17	20.27
101-110	8	-	-	25	37.5	-	37.5

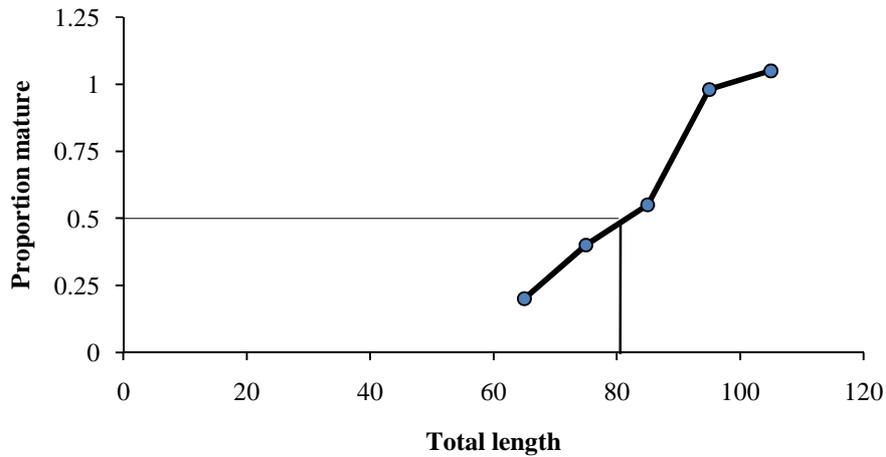


Figure 1: Length at first maturity in females of *A. quadrafasciatus*.

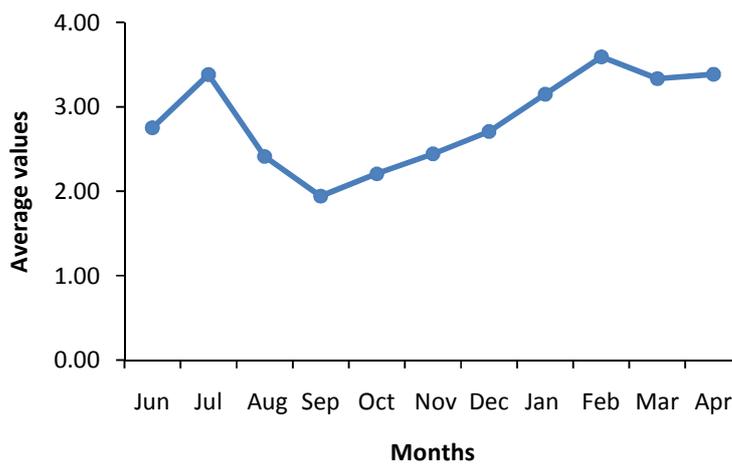


Figure 2: Gonado Somatic Index in females of *A. quadrafasciatus*.

**Maturation**

A scale of 6 stages of maturity of ovaries was adopted in this study.

Stage I (Immature): Ovaries were thin, narrow and elongated. Ovaries were translucent to whitish. Ova were invisible to naked eye. Ova were transparent. Ovaries were occupying 1/4<sup>th</sup> of the body cavity.

Stage II (Early maturing): Ovaries were cream in color and occupied about more than 1/4<sup>th</sup> of the body cavity. Ova appeared irregular and transparent. Ova attained a mean size of 0.23 mm.

Stage III (Maturing): Ovaries were thick, narrow, cylindrical and occupied half of the body cavity. They were pale pink in color, blood capillaries are not distinct. Ova were clearly visible to naked eye. Maturing ova appeared on microscope as semi-transparent with yolk granules. Ova attained a mean size of 0.27 mm.

Stage IV (Mature): Ovaries occupied more than half of the body cavity. They were pink in color with numerous blood capillaries over the entire ovary. Ova were opaque and filled with yolk. Ova attain a mean size of 31 mm.

Stage V (Ripe): Ovaries with thin ovarian wall and fully stretched to the point of bursting at the mere touch of needle and releasing several loosely bound ripe ova. Ovaries were occupying entire body cavity. Ovaries were reddish in color with numerous blood capillaries. The ripe ova are large and spherical with a mean size of 0.39 mm.

Stage VI (Spent): The bulky ovaries were very much reduced, bag like and hollow. Some disintegrated, free and loosely connected mature ova were present in the ovary, besides the large maturing and immature ova.

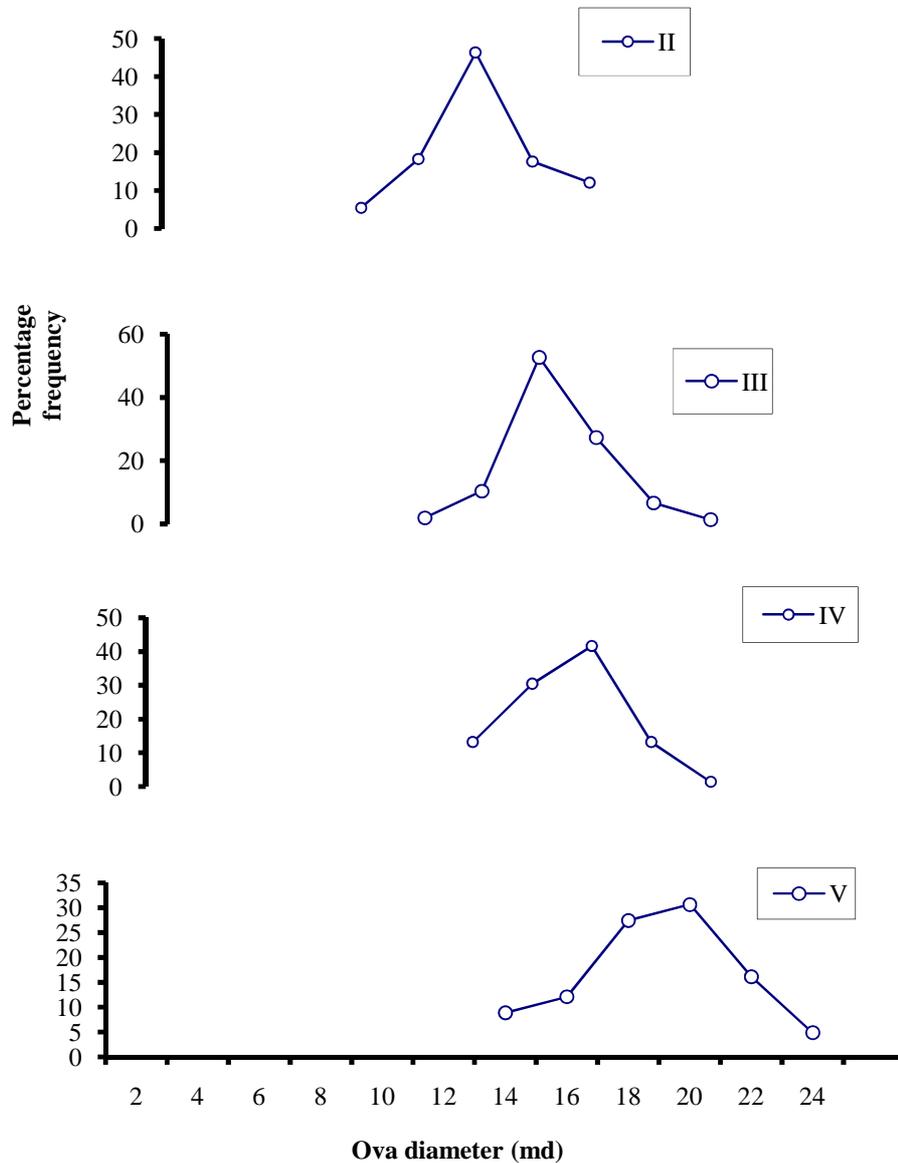


Figure 3: Ova - diameter frequency distribution in ovaries of different stages of maturation in *A. quadrifasciatus*

**Length at first maturity (Lm)**

The percentage frequency distribution of mature females in different stages of ovary in different length groups was given in Table 3. Ripe females were observed only from 65 mm onwards. However majority of females in the range of 81-90 mm total length formed the spawning population and constitute a sizable quantity in the trawling grounds off Visakhapatnam. The average length at which 50% of the individuals attain first sexual maturity was 82 mm length in females (Figure 1).

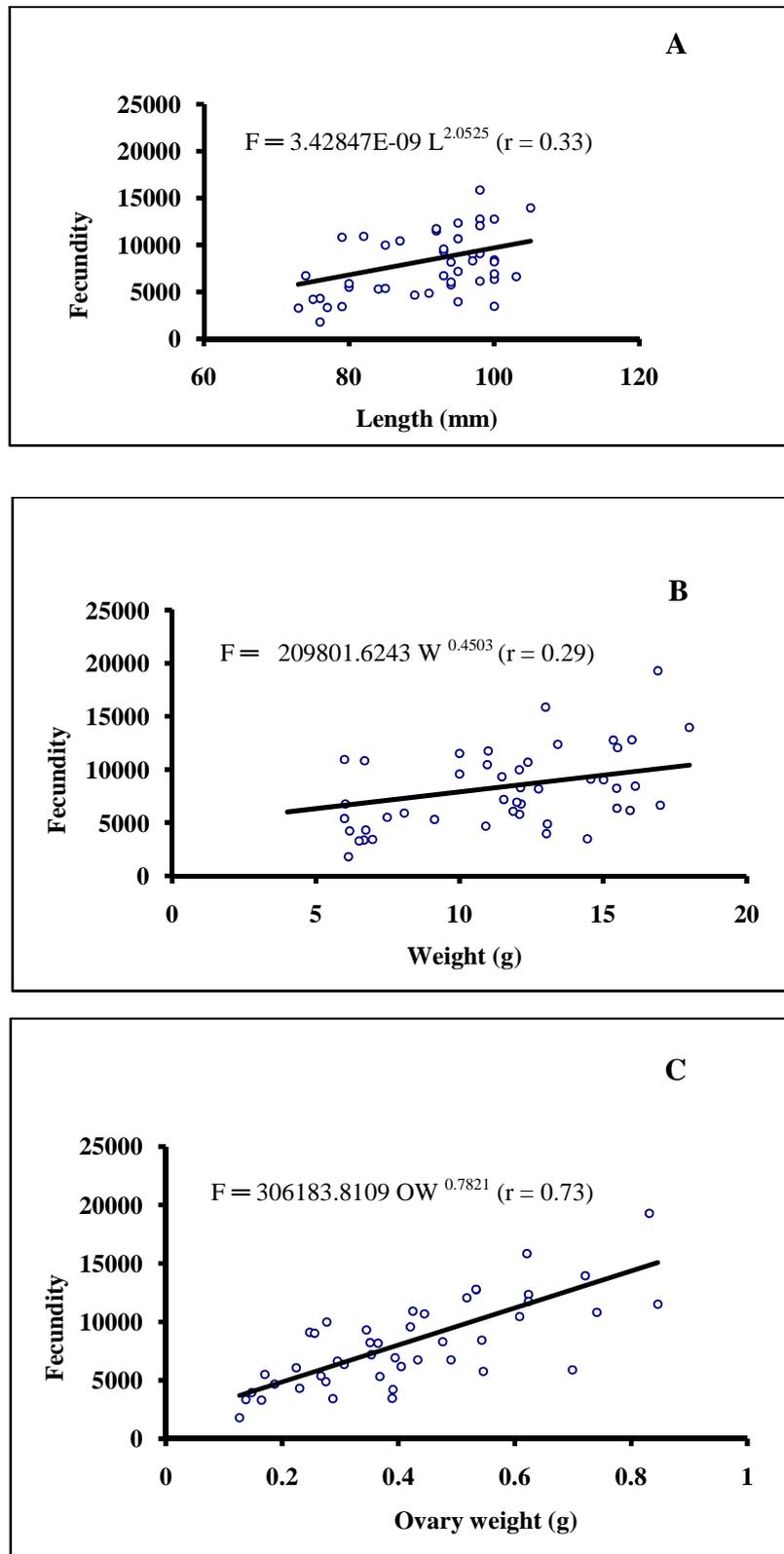


Figure 4: Relationship between fecundity and fish length (A), fish weight (B) and ovary weight (C) in *A. quadrifasciatus*

**Spawning season**

Monthly percentage occurrence of females in different stages of maturity during the study period from Jun 2006 to May 2007 was given in Table 3. Mature and ripe fish in stage V were observed almost throughout the study period with peak from Feb to Apr 2007. The spent ovaries were observed throughout the study period except Jun06, Jul06 and Dec 2006. The ovary in Stage III was observed in entire study period. The availability of more number of fishes with ripe ovaries (V) during Feb to Apr 2007 showed that the peak spawning season of *A. quadrifasciatus* in the trawling grounds off Visakhapatnam.

**Gonado Somatic Index (GSI)**

The GSI has been found to be high during Feb07 – Apr07 in females indicating that spawning activity takes place during these months. A fall in GSI has been seen in Aug 06 to Nov 06 in females indicating the cessation of spawning activity in females of *A. quadrafasciatus* (Figure 2).

**Development of ova to maturity and spawning**

Ova diameter frequency in different stages of maturity showed that a large number of immature ova, from which a batch of ova destined to mature and spawn in the ensuing season, separates out and progressively increase in size with the advancement of maturity (Figure 3). The ova were distributed around a modal value of 11-12md (0.22 to 0.24 mm) in stage II. It progressed in stage III, at a modal value of 13 – 14md (0.26 to 0.28 mm). In stage IV, one mode was formed at 15-16md (0.30 to 0.32 mm). In stage V also one mode was formed at 19-20md (0.38 to 0.40 mm), which are ready to release. Figure 3 showed that the ovary of *A. quadrifasciatus* contains different stages of ova, indicating it to be a fractional spawner.

**Fecundity**

The fecundity ranged from 1808 to 19678 with mean of  $8332.69 \pm 597.1461$  in length ranging from 73 to 105 mm. The relationship between fecundity (F) and fish length (L), fish weight (W) and ovary weight (OW) showed linearity (Figures 4A, B and C). The equations obtained were:

$$F = 3.42847E-09 L^{2.0525} \quad (r = 0.33)$$

$$F = 209801.6243 W^{0.4503} \quad (r = 0.29)$$

$$F = 306183.8109 OW^{0.7821} \quad (r = 0.73)$$

**DISCUSSION**

There has always been a male dominance, many times leading to an overall dominance of males in the sample, especially towards the breeding period of the fish [1]. The proportion of females appeared to be lower during the beginning of breeding season [1]. In the present investigation on *A. quadrifasciatus*, sex ratio analysis also revealed that males dominated the catches during the study period. Chi square analysis indicated that there was a significant difference ( $p < 0.05$ ) between the sexes in their occurrence.

Prabhu [15] followed a scale of five stages of maturity in the investigations on the biology of *Trichurus haumela*. Zaki *et al.*, [23] described seven stages of maturity of fish in *Sardinella longiceps* from the Sohar coast, Oman. Krishna Moorthy [11] made a slight modification of the scale used by Prabhu [15] and adopted a scale of six stages of maturity. Rukmini Sirisha and Yedukondala Rao [17] also described six stages of maturity in puffer fish *Lagocephalus spadiceus* from Visakhapatnam. In the present investigation also a scale of six stages of maturity was adopted to evaluate variations in frequency of maturity stages more precisely and to determine the spawning period specifically.

The size at first maturity was given as 79 mm TL by Garnaud [5]; >55mm TL by Klein [10] for *Apogon imberbis*. Kume *et al.*, [12] reported that the sexual maturity was attained at 60mm TL in *Apogon lineatus*. In the present investigation the size at first maturity was reported at 82mm in *A. quadrifasciatus*. This was slightly higher than earlier studies, may be due to species variations. Most of the females with ripe ovaries belonging to 81-90 mm length groups in *A. quadrifasciatus*. Hence these length groups in females formed the spawning populations at Visakhapatnam. It was also evident that the size at first maturity falls in their respective length groups.

*A. quadrifasciatus* studied in the present investigation spawn throughout the year with peak in February – April. It was evident that the spawning seasons of tropical marine fishes were of relatively longer durations [16]. Ova diameter frequency showed that the mature/ripe ovary contains ova with different stages of maturity, it appears that

*A. quadrifasciatus* was a fractional spawner. According to ova diameter frequency curve, *A. quadrifasciatus* release their ripe eggs in a single batch during spawning season and formed one mode in each stage which was more or less similar to that of the findings of Zaki *et al.*, [23]. Most of the earlier workers were also reported fractional spawning in related marine fishes [6, 7, 8, 10, 12, 13, 14 and 17].

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