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SOME ASPECTS OF BIOLOGY OF TAIL EYED GOBY *PARACHAETURICHTHYS POLYNEMA* (BLEEKER, 1853), OFF VISAKHAPATNAM, EAST COAST OF INDIA

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Abstract

Sex ratio indicated that there was no significant difference ($p > 0.05$) between the sexes in their occurrence. A scale of five stage of maturity of gonads was identified in females. The mean length at first maturity was found to be 97mm in females. Peak spawning takes place during Jun to Dec. GSI was found to be high during Jun to Oct in males; Jun to Dec in females. Fecundity varied from 10,016 to 18,194 ova. *P. polynema* was a carnivore, feeds mostly on shrimp, fish, crab, gastropods, cephalopods and miscellaneous in the order of importance. There was no marked difference in the food composition between males and females. A common regression equation was given for both the sexes as $W = 0.000101672\ L^{2.4968}$ ($r = 0.90$). Analysis of covariance conducted to test the difference between the regression slopes of males and females showed no significant difference ($P>0.05$). Relative condition factor was low during Sep to Dec in males and during Jun and Aug-Nov in females of *P. polynema*.

Key words: *Parachaeturichthys polynema*, spawning biology, food and feeding habits, length-weight relationship, Visakhapatnam

1. 1ntroduction

Parachaeturichthys polynema belongs to the family Gobiidae of order Perciformes. It is commonly called as tail eyed goby found in Indo-West Pacific, South to Natal, South Africa, India and Japan. Gobies are inhabitants of Seas, rarely enters estuaries, few fresh water, with about 220 genera and 1600 species of which 1200 species in Indo-Pacific (Smith and Heemstra, 1986). *P. polynema* captured by trawl nets and are treated as by-catches at Visakhapatnam. Among the different groups of fishes found in the by - catches, *Uranoscopus archaeonema* (13.54%), *Photopectoralis bindus* (9.75%), *Apogon quadrifasciatus* (7.91%) and *P. polynema* (7.73%) are dominant (Yedukondala Rao *et al.*, 2013). This species is not commercially important as it is found to contain Tetrodotoxin (TTX) and Anhydrotetrodotoxin (Anh-TTX) (Lin, *et al.*, 2000). Systematic account of some species of gobiids has been undertaken by several authors (Day, 1889, Anandale, 1919, Pannikkar, 1937, Koumans, 1953, and Mutsaddi and Bal, 1973). Toxicity studies on gobies were conducted since 1970s but no work on biology has been undertaken so far. Considering the ecological and medicinal importance of *P. polynema*, the present study aims to provide some basic information on maturation and spawning, food and feeding habits and length-weight relationship of *P. polynema* as a first attempt.

2. Materials and Methods

The present study was based on 261 specimens of *P. polynema* (males: 130; females: 131) ranging in size from 58mm to 160mm and weight 2.13g to 22.54g collected from commercial trawl catches at Visakhapatnam fishing harbor (Plate. 1) twice in a month during January to December 2008. The samples were not available during May due to fishing holidays from April 15th to May 31st which has been implementing 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 ratio of the sampled population was analyzed according to month. Maturity of the gonads was determined by external appearance like color, size, area occupied by them in the body cavity and microscopic observations of the ova (Prabhu, 1955).

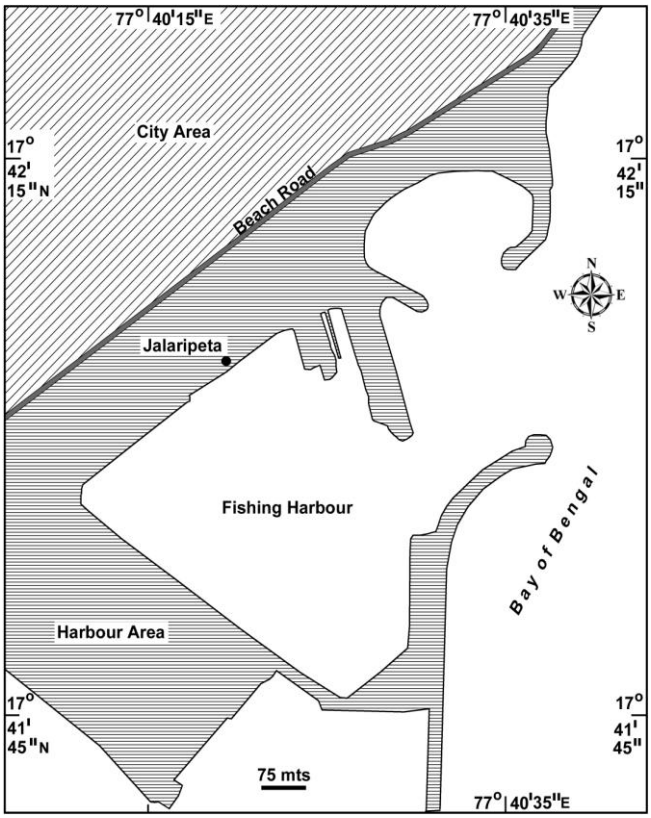


Plate. 1: Map of the study area: Visakhapatnam Fishing Harbor, Bay of Bengal

The mean length at first maturity (Lm) was determined for females by fitting logistic curve (King, 1995). To determine the length at first maturity, females were grouped into 10mm length intervals and the gonads of stage III and above (mature and ripe) were considered for this study. The average length at which 50% of the population attains maturity was considered as length at first maturity.

Percentage occurrence of matured fishes (fishes with stage III and IV gonads) in different months and Gonado Somatic Index (GSI) was used to determine the spawning season (West, 1990). The Gonado Somatic Index (GSI) was calculated using the formula: GSI = GW/FW × 100, where GW represents gonad weight (g); TW: the total body weight (g).

Measurement of ova diameter (Clark, 1934) 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. About 500 – 600 ova were measured from maturing, mature and ripe ovaries (stage II to IV). 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 gravimetrically (Simpson, 1959) was based on intact ovaries of ripe stage collected during the study period. Relationships between fecundity (F) against fish length (L), fish weight (W) and ovary weight (OW) were estimated using linear regression equation (Bagenal, 1978) as $F = aX^b$ where a = constant, b = exponent, F = fecundity, X = total length/ body weight/ gonad weight. Fecundity values were plotted against the respective total length, weight and ovary weight of fish.

For study of food and feeding habits, the stomachs were separated and kept separately in 5% formalin for about fortnight. Five categories of stomach fullness namely empty, one fourth, half, three fourth and full could be recognized based on the nature of stomach folds (Rao, 1964a) and their percentage was calculated. Each stomach was considered as a unit and the stomach contents were first identified qualitatively to the nearest taxon possible and their quantity was determined volumetrically. The points gained by each food item in all the stomachs examined in the samples were used to calculate the percentage of different food items (Hynes, 1950).

The length -weight relationship (LWR) was derived using exponential hypothetical formula $W = aL^b$ (Le Cren, 1951) where W is body weight (g), L is total length (mm), 'a' is a coefficient related to body form and 'b' is an exponent indicating isometric growth when equal to 3 (Sangun *et al.*, 2007). For testing the difference between the regression slopes of males and females, analysis of covariance was employed (Snedecor and Cochran, 1967). The monthly relative condition factor (Kn) for males and females was estimated adapting the formula of Le Cren (1951). Statistical analysis was carried out by Micro Soft Excel.

3. Results

3.1 Sex ratio

Trends in the ratio of males and females in different months from Jan to Dec, 2008 are shown in Table: 1. Males dominated the catches during Mar, Sep, and Dec. Females dominated in Feb, Aug, Oct and Nov. The sex ratio for male to female during the period was 1:1.01.

Chi square analysis of the data for the period from Jan to Dec, 2008 indicated that there was no significant difference ($p > 0.05$) between the sexes in their occurrence.

Table1: Month-wise sex ratio of *P. polynema* at Visakhapatnam

Month	Males	Females	% of males	% of females	Male : Female
Jan	1	3	25.00	75.00	1: 3
Feb	19	20	48.72	51.28	1: 1.05
Mar	6	3	66.67	33.33	1: 0.50
Apr	2	2	50.00	50.00	1: 1.00
May	-	-	-	-	-
Jun	22	22	50.00	50.00	1: 1.00
Jul	2	2	50.00	50.00	1: 1.00
Aug	11	21	34.38	65.62	1: 1.91
Sep	7	2	77.78	22.22	1: 0.29
Oct	3	9	25.00	75.00	1: 3.00
Nov	10	19	34.48	65.52	1: 1.90
Dec	47	28	62.66	37.34	1: 0.60
Total	130	131	49.80	50.19	1: 1.01
χ^2= 18.5488, P= 0.61405, Not Significant (p > 0.05)					

3.2 Maturation

A scale of 5 stages of maturity of ovaries was adopted in this study.

Stage I (Immature):

The ovaries were thin, narrow, cylindrical and translucent. Ova were invisible to naked eye. The ova were transparent. Ovaries occupy 1/4th of the body cavity. Ovaries were yellowish in color.

Stage II (Maturing):

The ovaries were reddish and occupying about more than 1/4th of the body cavity. Ova attained a model size of 9 – 10md (0.18 to 0.20mm.).

Stage III (Mature):

The ovaries were occupying more than half of the body cavity, becoming bulky. The ovaries were yellowish to red in color with numerous blood capillaries over the entire ovary. Ova were opaque and filled with yolk. Ova attained a model size of 13 -14md (0.26 to 0.28mm).

Stage IV (Ripe):

Ovaries were occupying more than 3/4th of the body cavity. Ovaries were orange red in color with numerous blood capillaries. The ripe ova were large and spherical with a model size of 15 – 16md (0.30 to 0.32mm).

Stage V (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.

3.3 Length at first maturity (LM)

The percentage frequency of mature females in different stages of ovary in different length groups was given in Table 2. Ripe females were observed only from 91mm onwards. However majority of females in the range of 91-140mm 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 97mm length in females (Figure 1).

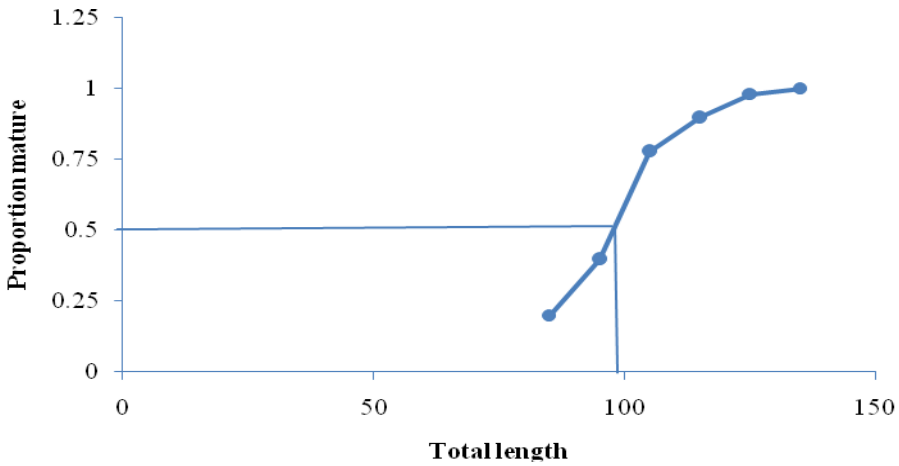


Figure1: Length at first maturity in females

Table 2: Length –wise percentage frequency distribution of females with different stages of maturation

Lengths	Total No.	I	II	III	IV	Spent
71-80	4	100.00	-	-	-	-
81-90	16	50.00	37.50	12.50	-	-
91-100	37	2.70	24.33	45.95	24.32	2.70
101-110	39	-	-	7.69	66.67	25.64
111-120	19	-	-	5.26	47.37	47.37
121-130	7	-	-	-	14.28	85.72
131-140	9	-	-	-	22.22	77.78
141-150	1	-	-	-	-	100.00

3.4 Spawning season

Monthly percentage occurrence of females in different stages of maturity during the study period from Jan to Dec, 2008 was given in Table 3. The frequencies of mature and ripe fish in Stage IV available during Feb, Mar and Jun-Dec. Third stage was observed during Jan, Feb, Jun-Aug, Nov and Dec. The availability of more number of fishes with ripe ovaries (IV) during Jun – Dec shows that the peak spawning season of *P. polynema* in the trawling grounds off Visakhapatnam.

Table 3: Month –wise percentage frequency distribution of females with different stages of maturation

Months	Total No.	I	II	III	IV	Spent
Jan	3	-	33.33	66.67	-	-
Feb	20	15	20	25	10	30
Mar	3	-	-	-	66.67	33.33
Apr	2	50	50	-	-	-
May	-	-	-	-	-	-
Jun	22	-	-	18.18	31.82	50
Jul	2	-	-	50	50	-
Aug	21	9.52	9.52	14.29	52.38	14.29
Sep	2	-	-	-	50	50
Oct	9	22.22	22.22	-	33.34	22.22
Nov	19	-	10.53	10.53	47.37	31.57
Dec	28	17.86	10.71	17.86	42.86	10.71

3.5 Gonado Somatic Index (GSI)

The GSI has been found to be high during Mar and Jun to Oct in males; Jun to Dec in females indicating that spawning activity takes place during these periods. A fall in GSI values has been seen in Feb, Apr and Dec in males; Jan and Apr in females indicating the cessation of spawning activity in males and females of *P. polynema* (Figure 2).

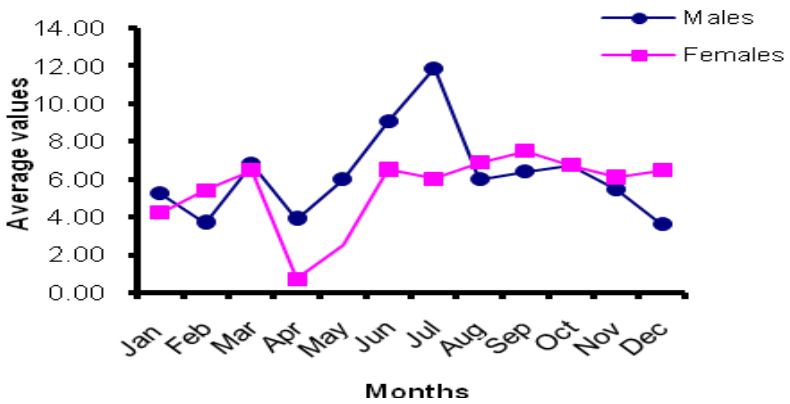


Figure2: Gonado Somatic Index of *P. polynema*

3.6 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). A batch of ova released from parent stock and formed only one mode around 9-10md (0.18 to 0.20mm) in Stage II. It progressed in Stage III and formed one mode around 13 – 14md (0.26 to 0.28mm). In Stage IV also, one mode was formed around 15-16md (0.30 to 0.32mm), which are ready to release. Thus it appears that *P. polynema* releases ripe eggs in one or two batches during the spawning season.

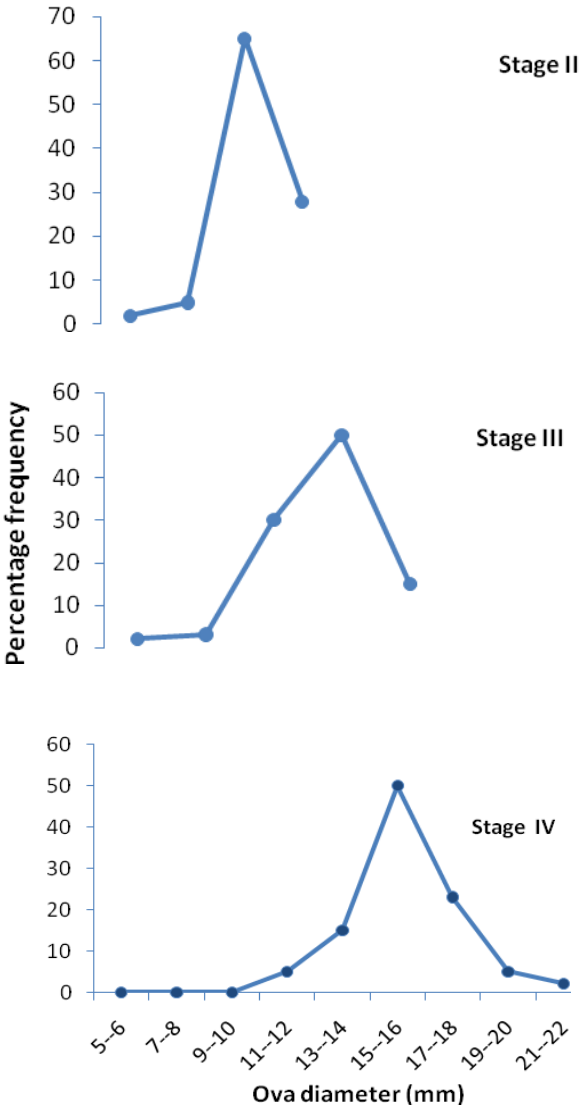


Figure 3: Ova diameter frequency distribution in ovaries of different stages of maturation in *P. polynema.*

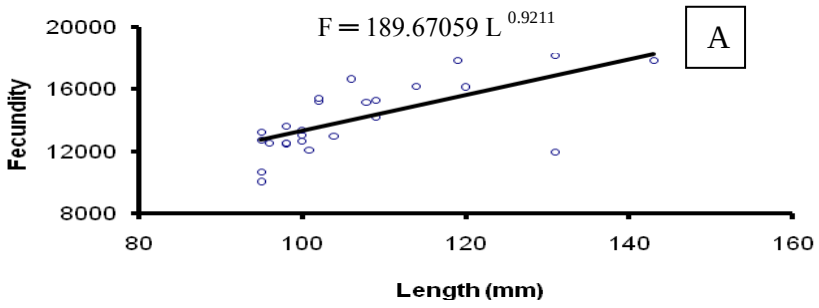
3.7 Fecundity

The fecundity ranged from 10,016 to 18,194 with mean 14,088 ± 442.2976 in length ranging from 95-143mm. The relationship between fecundity (F) and fish length (L), fish weight (W) and ovary weight (OW) showed linearity. (Figure 4 A, B and C). The equations obtained were:

$F = 189.67059\ L^{0.9211}$

$F = 5445.02653\ W^{0.3978}$

$F = 16749.42876\ OW^{0.3317}$



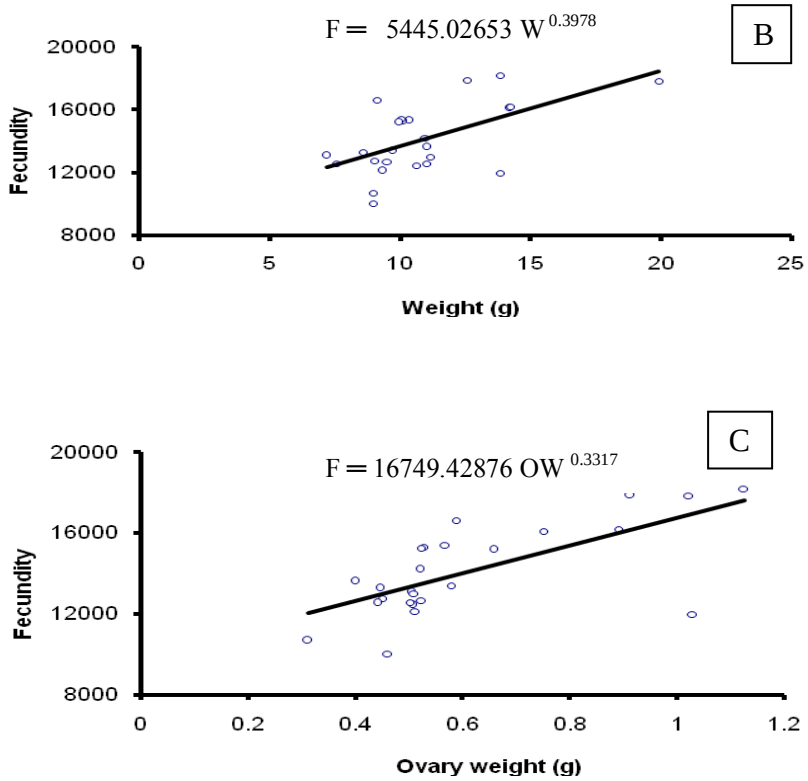


Figure 4: Relationship between fecundity and fish length, fish weight and ovary weight of *P. polynema*

3.8 Composition of food

The food items were classified into seven major groups in guts of *P. polynema* which were shrimp, fish, crab, gastropods, cephalopods, miscellaneous and digested matter. Regular food items in the order of importance (overall percentage composition) during Jan to Dec, 2008 (Figure 5) were shrimp (24.15%), fish (20.35%), crab (10.86%), gastropods (9.79%), miscellaneous (1.65%) cephalopods (0.39%) besides highest amount of digested matter (32.81%). The random variations of stomachs with different intensities of feeding in different months showed that high feeding intensity was observed during Feb, Mar and Apr. Low feeding intensity was observed during Jun-Dec (Table 4).

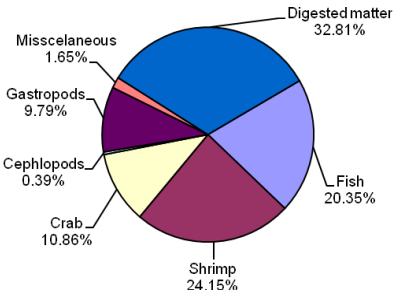


Figure 5: Percentage composition of different food items in gut of *P. polynema*

Table 4: Month-wise percentage occurrence of guts in various degrees of fullness

Months	N	Gorged	Full	3/4	Half	1/4	Empty
Jan	4	2.27	-	-	-	72.73	25.00
Feb	39	-	4.84	7.12	7.69	56.70	23.65
Mar	9	-	3.45	3.45	22.22	33.33	37.55
Apr	4	-	2.66	2.68	-	69.66	25.00
May	-	-	-	-	-	-	-
Jun	44	-	2.27	-	15.91	40.91	40.91
Jul	4	-	-	-	25.00	50.00	25.00
Aug	32	-	-	-	6.25	68.75	25.00
Sep	9	-	-	-	11.11	55.56	33.33
Oct	12	-	-	-	33.33	33.33	33.34
Nov	29	-	-	3.45	13.79	55.17	27.59
Dec	75	-	1.33	-	4.00	50.66	44.01

3.9 Length – weight relationship (LWR)

Estimations of the constants 'a' and 'b' in the linear form were made using the method of least squares in the logarithmic form:

Males W = 8.7096E-05 $L^{2.4785}$ (r = 0.92)
Females W = 8.3599E-05 $L^{2.5152}$ (r = 0.89)
Sex combined: W = 0.000101672 $L^{2.4968}$ (r = 0.90)

The comparision of regression lines in Table 5 showed no significant difference ($p>0.05$) between the slopes of the two sexes at 5% level and showed negative allometric growth for combined sexes. The scattered diagram of observed weight against length of all the specimens reveals a curvi – linear relation between the two variables (Figure 6 and 7).

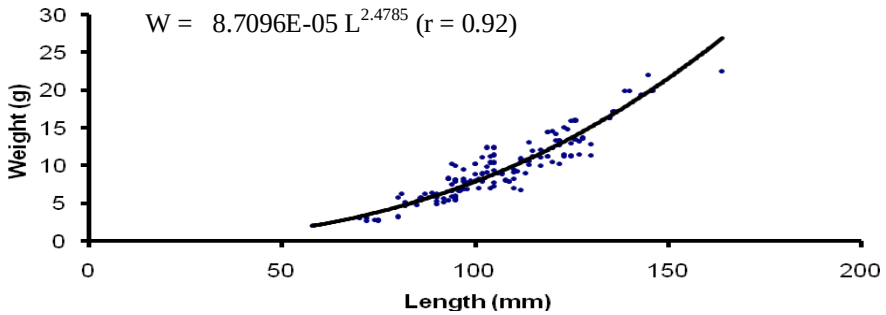


Figure 6: Scattered diagram showing relationship between length and weight in males of *P. polynema*

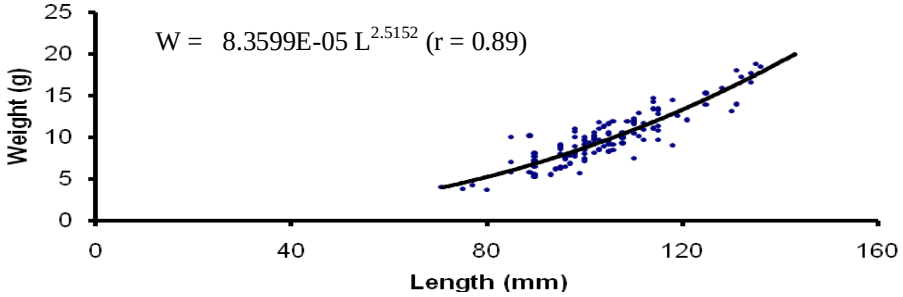


Figure 7: Scattered diagram showing relationship between length and weight in females of *P. polynema*

Table 5: Comparision of regression lines of length-weight relationship in males and females of *P. polynema*

	D.F.	X^2	Y^2	XY	Regression Coefficient		D.F.	SS	MSS
					Intercept (a)	Slope (b)			
Within Males	131	4.097276	0.91606	1.937358	-4.0600	2.4785	130	0.720286	
Females	132	4.059016	0.979308	1.993747	-4.0778	2.5152	131	4.4167787	
							261	5.137064	0.01968
Pooled	263	8.15621	1.89536	3.93109	-3.9928	2.4968	262	5.100439	0.001946
			Difference between slopes				1	0.036625	0.0036625

Slopes F = 1.861026 D.F. 1,261 P= 0.173682 Not Significant at 5% level

3.10 Relative condition factor

Variations in the relative condition factor in different months (Figure 8) were studied for both males and females. Seasonal variations in the relative condition factor showed high values in males throughout the study period, except from Sep to Dec. High values were observed in Jan, Mar, Apr and Jul in females. Low values were observed from Jun and Aug to Nov in females.

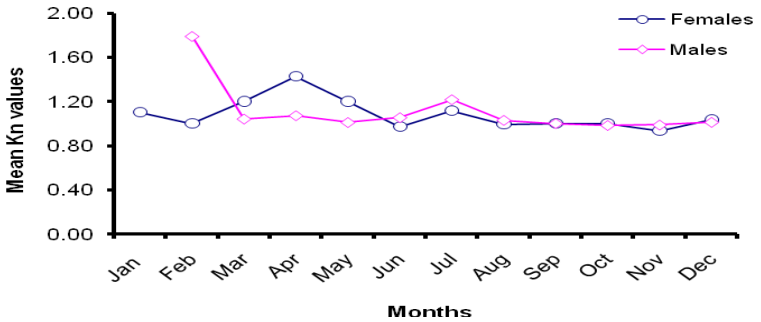


Figure 8: Relative condition factor in males and females of ***P. polynema***

4. Discussion

Sex ratio analysis reveals that there was no significant difference between the sexes in *P. polynema* populations at Visakhapatnam. Female dominance was noticed in other gobid species *Boleophthalmus dussumieri* (Hoda, 1986), *Gobius vittatus* (Marcelo Kovacic, 2007), *Boleophthalmus boddaerti* (Gore et al., 2014) but male dominance was noticed in *Gobius niger* (Ferid Hajji et al., 2013) and in *Parachaeturichthys ocellatus* (Gore et al., 2014). These variations may be attributed to species diversity, life span of sexes and geographical conditions of the study area.

A scale of five stages of gonad maturity in females of *P. polynema* was adopted to evaluate variations in frequency of maturity stages more precisely and to determine the spawning period specifically. Six stages of gonad maturity was described in other finfish species *Lagocephalus spadiceus* (Rukmini Sirisha and Yedukondala Rao, 2007), *Lagocephalus lunaris* (Rukmini Sirisha and Yedukondala Rao, 2013), *Apogon quadrifasciatus* (Naga Krishna Veni et al., 2014) represented in the by-catches off Visakhapatnam. A scale of seven stages of gonad maturity was also noticed in *Boleophthalmus dussumieri* (Hoda, 1986). These variations may be due to variations in gonad development and spawning periodicity.

The size at first maturity was observed to be 97mm in females of *P. polynema*. Most number of females with ripe ovaries fall in 91-140mm length groups. Hence these length groups formed the spawning populations at Visakhapatnam. Ferid Hajji et al., (2013) reported size at first maturity in females of *Gobius niger* was 96.9mm. This was almost similar to that of present study. The size at first maturity of other finfish species was found to be 170mm in *L. spadiceus* (Rukmini Sirisha and Yedukondala Rao, 2007), 141mm in *Lagocephalus lunaris* (Rukmini Sirisha and Yedukondala Rao, 2013) and 82mm in *Apogon quadrifasciatus* (Naga Krishna Veni et al., 2014) represented in trawl net by-catches at Visakhapatnam. Lowest length at first maturity (32.8 cm) was noticed in *Gobius vittatus* (Marcelo Kovacic, 2007). These variations may be attributed to species diversity, maturity, age, growth and maximum length of fish besides environmental conditions.

P. polynema spawns throughout the year with peak during Jun-Dec and release their eggs one or two times in a spawning season because ripe ovary in *P. polynema* contains large number of immature ova besides ripe ova. Fractional spawning was also noticed in other gobid, *Gobius vittatus* from Northern Adriatic Sea (Marcelo Kovacic, 2007). Mahadevan Pillai (1972) stated that the tropical marine fish species spawn more than once in a year and that the spawning season was protracted. Similar findings were also noticed in Indian silver bellies (Murthy 1983, 1990; Murthy et al., 2003; Abraham et al., 2011), threadfin breams (Yedukondala Rao 2002), puffer fishes (Rukmini Sirisha and Yedukondala Rao 2007, 2013), Apogonids (Naga Krishna Veni et al., 2014).

The GSI has been found to be high during Jun-Oct in males, Jun-Dec in females of *P. polynema* which corresponds to months of peak spawning seasons. A fall in GSI values were seen in Feb, Apr and Dec in males; Jan, Feb and Apr in females indicating the cessation of spawning activity. The progression of monthly values of the Gonado Somatic Index indicated the spawning season of fishes (Marcelo Kovacic, 2007; Rukmini Sirisha and Yedukondala Rao, 2007, 2013; Abraham et al., 2011; Ferid Hajji et al., 2013; Naga Krishna Veni et al., 2014).

The measurement of the oocyte diameter showed that a ripe ovary contained fully ripe oocytes (0.30-0.32mm), mature oocytes (0.26-0.28mm), maturing oocytes (0.18-0.20mm) and numerous very small one (<0.10mm). The presence of four clearly distinct sizes of oocytes in ripe ovaries indicated that each female could spawn atleast twice or thrice during the breeding season. Similar findings were also noticed in other marine fishes (Jayawardane and Dayaratne, 1998; Yedukondala Rao, 2002; Marcelo Kovacic, 2007; Rukmini Sirisha and Yedukondala Rao 2007, 2013; Ferid Hajji et al., 2013; Naga Krishna Veni et al., 2014).

Fecundity ranged from 10,016 to 18,194 with mean 14,088 ±442.2976 and showed linearity with length weight of fish and ovary weight in *P. polynema*. Low fecundity was also noticed in *Gobius vittatus* (Marcelo Kovacic, 2007), *Gobius niger* (Ferid Hajji et al., 2013), *Leiognathus brevirostris* (Jayawardane and Dayaratne, 1998), *Apogon quadrifasciatus* (Naga Krishna Veni et al., 2014). Marcelo Kovacic, (2007) stated that the number of oocyte classes found in the ripe ovaries does not necessarily reflect the number of batches produced during one season, because of possible recruitment from numerous immature oocytes. He also stated that multiple spawning and the parental care may increase the reproductive success in the striped gobids and compensate for the relatively low fecundity. The linear relationship between fecundity and fish length, weight and ovary weight was also noticed in pufferfishes (Rukmini Sirisha and Yedukondala Rao 2007, 2013) and apogonids (Naga Krishna Veni et al., 2014).

P. polynema was a benthic carnivore, feeding mostly on shrimps, fish, crab, gastropods and cephalopods in the order of importance. There was no marked difference in the food composition between males and females of *P. polynema.* Similar findings were also noticed in other tropical benthic fishes like *Nemipterus randalli* (Yedukondala Rao

2003), *Lagocephalus spadiceus* (Yedukondala Rao and Rukmini Sirisha, 2005) and *Apogon quadrifasciatus* (Naga Krishna Veni et al., 2008).

According to Morey *et al.,* (2003) and Sangun *et al*., (2007), the growth was found to be isometric if b = 3, negative allometric if b < 3, positive allometric if b > 3. In the present study on *P. polynema*, a common regression equation was given for both the sexes as Log W = 0.000101672 $L^{2.4968}$ which showed negative allometric growth. Negative allometric growth was also noticed in *Epinephelus epistictus* (Sujatha et al., 2010*), Secutor insidiator* and *Gazza minuta* (Soba Joe and Sitarami Reddy, 2012), *Gobius niger* (Josip et al., 2013), *Lagocephalus lunaris* (Rukmini Sirisha and Yedukondala Rao, 2013). The regression coefficient of males and females showed a significant difference between two sexes in the present study. Similar findings were also noticed in *Nemipterus japonicus* (Murthy, 1984), *Nemipterus randalli* (Yedukondala Rao and Shameem, 1999), *Lagocephalus spadiceus* (Rukmini Sirisha and Yedukondala Rao, 2005), *Apogon quadrifasciatus* (Yedukondala Rao et al., 2008), *Lagocephalus lunaris* (Rukmini Sirisha and Yedukondala Rao, 2013).

Low values of Kn indicated spawning season where as high values indicated fattening in fishes (Le Cren, 1951). Kn values were found to be low during Sep-Dec in males; Sep-Nov in females which may indicate spawning season. It was also evident that the more number of mature and spent fishes represented in these months.

References

Abraham, K. J., Murthy, V. S. R. and Joshi, K. K. (2011). Reproductive biology of *Leiognathus splendens* (Cuvier) from Kochi, south-west coast of India. *Indian Journal of Fisheries,* 58 (3), pp. 23-31.

Anandale, F. (1919). The fauna of certain small streams of Bombay Presidency. *Rec. Ind. Mits.*, 16, pp. 125-129.

Bagenal, T. B. (1978). Aspects of fish fecundity. In Gerking, S.D. (ed.), *Ecology of freshwater fish production*. Blackwell Scientific Publications: Oxford.

Clark, F.N. (1934). Maturity of the California Sardine (*Sardina caerulea*) determined by ova diameter measurements. *Fish. Bulletin. California Division of Fish and Game,* 42, pp. 49.

Day, F. (1967). The fishes of India, *Fish* 1 and 2, Jagamander Agency, New Delhi.

Ferid Hajji, Amira Ouannes-Ghorbel, Mohamed Ghorbel and Othman Jarboui. (2013). Reproductive biology of the black goby, *Gobius niger* (Teleostei: Gobiidae), in the Gulf of Gabe`s (Tunisia, Central Mediterranean). *Journal of the Marine Biological Association of the United Kingdom,* 93(6), pp. 1685–1693.

Gore, B. M., Panikker, B. A. and Katchi, V. I. (2014). Comparative account of sex ratio and sexual dimorphism in two species of gobiids from the Vasai creek of Mumbai. *Life Sciences Leaflets,* 49, pp. 44-47.

Hoda, S. M. S. (1986a). Maturation and fecundity of the mudskipper *Boleophthalmus dussumieri* Cuv & Val from the Karachi coast. *Mahasagar- Bulletin of the National Institute of Oceanography,* 19, pp. 73-78.

Hynes, H. B. N. (1950). The food of stickle-backs (*Gasterosteus aculeatus* and *Pygosteus pungitis*) with a review of methods used in studies of the food of fishes. *Journal of Animal Ecology*, 19, pp. 36-58.

Jayawardane, P. A. A. T. and Dayaratne, P. (1998). Reproductive Biology of shortnose pony fish *Leiognathus brevirostris* (Valenciennes) from Portugal Bay in the Puttalam Estuary, Srilanka. *Asian Fisheries Science,* 10, pp. 189-200.

Josip BOBAN, Igor ISAJLOVIĆ, Barbara ZORICA*, Vanja ČIKEŠ KEČ and Nedo VRGOČ. (2013). Biometry and distribution of the black goby *Gobius niger* (Linnaeus, 1758) in the Adriatic Sea. ACTA ADRIAT, 54(2), pp. 265 – 272.

King, M. (1995). *Fisheries Biology, Assessment and Management*. Fishing News Books: Blackwell Science Ltd, London.

Koumans, F. P. (1942). Gobioid fishes of India. *Mem. Ind. Mus.*, 13, pp. 206-329.

Le Cren, C.P., (1951). Length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*, 20(2), pp. 201-219.

Lin, S. J., Hwang, D. F., Shao, K. T. and Jeng, S.S. (2000). Toxicity of Taiwanese gobies. *Fisheries Science,* 66, pp. 547-552.

Marcelo Kovac˘ic. (2007). Reproductive biology of the striped goby, *Gobius vittatus* (gobiidae) in the Northern Adriatic Sea. *Scientia Marina,* 71(1), pp. 145-151.

Mahadevan Pillai K.V. (1972). Fecundity and spawning habits of some silver bellies. *Indian Journal of Fisheries,* 19, pp. 196-199.

Morey, G., Moranta, J., Massuti, E., Grau, A., Linde, M., Riera, F. and Morales-Nin, B, (2003). Weight-length relationships of littoral to lower slope fishes from the Western Mediterranean. *Fisheries Research,* 62, pp. 89-96.

Murthy, V. S. (1984). Observations on the fishes of threadfin breams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) from Kakinada. *Indian Journal of Fisheries,* 31(1), pp. 1-18.

Murthy, V. S. (1983). Observations on some aspects of biology of silver belly *Leiognathus bindus* (Valenciennes) from Kakinada. *Indian Journal of Fisheries,* 30 (1), pp. 61-68.

Murthy, V. S. (1990). Biology and population dynamics of the silver belly *Secutor insidiator* (Bloch) from Kakinada. *Journal of Marine Biological Association of India*, 32 (1/2), pp. 10-24.

Murty, V.S., Joshi, K. K. and Rekha, J. Nair. (2003). Silver bellies. In: Mohan Joseph, M and Jaya Prakash, A.A., (eds.). *Status of Exploited Marine Fishery Resources of India,* Central Marine Fisheries Research Institute: Cochin, pp. 127-132.

Mutsaddi, K. B. and Bal, D. V. (1973). Gobies from the intertidal region of Bombay. *Indian Journal of Fisheries*, 20 (2), pp. 475-486.

Naga Krishna Veni, D., Sudha Rani, D. and Yedukondala Rao, P. (2008). Food and feeding behaviour of *Apogon quadrifasciatus* Cuvier, 1828 populations off Visakhapatnam, east coast of India. *Journal of Aquatic Biol*ogy, 23 (1), pp. 73-76.

Naga Krishna Veni, D., Yedukondala Rao, P. and Rukmini Sirisha, I. (2014). Some aspects of reproductive biology of *Apogon quadrifasciatus*, Cuvier, 1828 collected from the trawling grounds off Visakhapatnam, east coast of India. *Advances in Applied Science Research,* 5(4), pp. 117-124.

Pannikkar, N. K. (1937). The Brackish water fauna of Madras. *Proc., Ind. Acad. Sci*, 6, pp. 284-336.

Prabhu, M.S. (1955). Some aspects of the biology of the ribbonfish, *Trichurus haumila* (Forsskal). *Indian Journal of Fisheries,* 2 (1), pp. 132-163.

Rao, K. S. (1964a). Food and feeding habits of fishes from trawl catches in the Bay of Bengal with observations of diurnal variations in the nature of food. *Indian Journal of Fisheries,* 11, pp. 277-314.

Rukmini Sirisha, I. and Yedukondala Rao, P. (2005). Length-weight relationship of puffer fish *Lagocephalus spadiceus* (Richardson, 1844) off Visakhapatnam, East Coast of India. *Journal of Aquatic Biol*ogy, 20 (2), pp. 161-164.

Rukmini Sirisha, I. and Yedukondala Rao, P. (2007). Reproductive biology of half-rough back pufferfish, *Lagocephalus spadiceus* (Richardson, 1844) off Visakhapatnam, east coast of India. *Journal of Marine Biological Association of India,* 49 (1), pp. 70-75.

Rukmini Sirisha, I. and Yedukondala Rao, P. (2013). Maturation and spawning of green-rough-back pufferfish, *Lagocephalus lunaris* (Bloch and Schneider, 1801) off Visakhapatnam, East coast of India. *International Journal of Current Biotechnology*, 1(10), pp. 8-14.

Rukmini Sirisha, I. and Yedukondala Rao, P. (2013). Length-weight relationship and growth of green-rough-back pufferfish *Lagocephalus lunaris* (Bloch and Schneider, 1801), off Visakhapatnam, east coast of India, *Advances in Applied Science Research*, 4(4), pp. 123-128.

Sangun, L., Akamca, E. and Akar, M. (2007). Weight-length relationships for 39 species from the north-eastern Mediterranean coast of Turkey. *Turkish Journal of fisheries and Aquatic Sciences*, 7, pp. 37-40.

Shoba Joe Kizhakudan and Sitarami Reddy, P. (2012). Length-weight relationship in three species of silver bellies from Chennai coast. *Indian Journal of fisheries*, 59(3), pp. 65-68.

Simpson, A.C., (1959). *Methods used for separating and counting the eggs in fecundity studies on the plaice (Pleuronectes platessa) and herring (Clupea herengus).* FAO Occasional Papers, Indo Pacific Fish Conference, No. 59/12.

Smith, M. M. & Heemstra, P. C. (1986). Smith's Sea Fishes. Springer Verlag, New York, pp. 1047.

Sujatha, K., Shrikanya Rao, K.V.L. and Padmavathi, P. (2010). Length-weight relationship of four species of *Epinephelus Bloch*, 1793 in the catches off Visakhapatnam, east coast of India. *Journal of Marine Biological Association of India*, 52(1), pp. 96-98.

Snedecor, G.W. and Cochran, W.G. (1967). Statistical methods. 6th edition, New Delhi: Oxford and IBH Publishing Co.

West, G. (1990). Methods of assessing ovarian development in fishes: A review. *Australian Journal of Marine and Freshwater Research*, 41, pp. 199-222.

Yedukondala Rao, P. and Shameem, A. (1999). A note on the length-weight relationship of *Nemipterus Randalli* Russell off Visakhapatnam coast. *Journal of Marine Biological Association of India*, 41(1 & 2), pp. 135-138.

Yedukondala Rao, P. (2002). Fecundity studies on *Nemipterus Randalli* Russell, 1986 off Visakhapatnam. *Journal of Aquatic Biol*ogy, 17 (2), pp. 67-68.

Yedukondala Rao, P. (2003). Food and feeding habits of *Nemipterus Randalli* Russell, 1986 off Visakhapatnam, Andhra Pradesh, India. *Journal of Aquatic Biol*ogy, 18 (1), pp. 55-57.

Yedukondala Rao, P. and Rukmini Sirisha, I. (2005). Food and feeding habits of pufferfish *Lagocephalus spadiceus* (Richardson, 1844) off Visakhapatnam, east coast of India. *Journal of Aquatic Biol*ogy, 20 (2), pp. 150-154.

Yedukondala Rao, P., Sudha Rani, D. and Naga Krishna Veni, D. (2008). Length-weight relationship of *Apogon quadrafasciates* Cuvier, 1828 (Perciformes: Apogonidae) off Visakhapatnam, east coast of India. *Journal of Aquatic Biol*ogy, 23 (1), pp. 77-79.

Yedukondala Rao, P., Naga Krishna Veni, D. and Rukmini Sirisha, I. (2013). Trawl net by-catches off Visakhapatnam with special reference to Finfish. *Advances in Applied Science Research*, 4(5), pp. 363-371.