

Original Article

Reproductive biology, maturation size and sex ratio of black tiger shrimp (*Penaeus monodon* Fabricius, 1798) from fishing grounds of Digha coast, West Bengal, India.

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Abstract: The present paper studies the reproductive biology, maturation size and sex ratio of *Penaeus monodon* collected from Digha fishing grounds, India during 2011-2013. A total of 633 individual of *P. monodon* were examined and among them 242 were males and 391 were females. The overall yearly sex ratio was observed to be 1:1.6 (males: females). Based on the results, the spawning season of *P. monodon* was mainly in January-February and was extended up to June. The first maturity was observed at 163.5 mm length. The estimated number of ova in the mature ovary ranged from 120155 to 961240 in *P. monodon*.

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Introduction

Penaeus monodon is the largest species among the penaeids prawns commercially known as Jumbo Tiger Prawn or Black Tiger Prawn. It is widely distributed and commercially very important species in India and national market. Rao (2000) studied the reproduction and the spawning of *P. monodon* and reported it to be heterosexual as is the case with all the penaeids. The females attain maturity at 196-200 mm and males at 166-170 mm TL. The five maturity stages distinguished in the ovary could be termed as immature, maturing, mature, ripe and spent. Fecundity varies from 200000 to 1000000 eggs depending on the size of the females. Spawning takes place in the sea at 40-80 m depth.

Knowledge of spawning seasons and distribution of spawning areas are important for the management of fisheries. The spawning seasons of penaeid shrimps are most commonly determined by the percentage of mature females present in the catch or from the changes in gonadal indices (Crococ and Kerr, 1983; Garcia, 1985; Bauer and Vega, 1992; Crococ and Coman, 1997; Minagawa et al., 2000; Crococ et al.,

2001; Costa and Fransozo, 2004; Aragon-Noriega and Garcia-Juarez, 2007). In the Philippines, spawning is year round but there seems to be two peak seasons in a year. February-March or July and October-November, although it varies from year to year (Motoh, 1981). Rajyalakshmi et al. (1985) reported the peak season as October-April corresponding to the post-monsoon season coinciding with an increase in the salinity along the Odisha coast, while it varies from place to place in Philippine and Taiwan (Su and Liao, 1986). Su et al. (1990) observed September-December as the peak season. However, there is no published information available till date on the breeding season, size at sexual maturity and sex ratio of *P. monodon* from Digha coast of West Bengal, India. The present study is to provide information on the reproductive biology including the breeding season, size at sexual maturity and sex ratio of *P. monodon* in coastal waters of Digha coast, India.

Materials and Methods

The samples of *P. monodon* were collected from

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commercial catches of Digha Mohana landing centre caught by trawlers from Bay of Bengal of West Bengal coast during 2011-2013. Shrimps with petasma and presence of spermatophores in the terminal ampoule were taken as matured males. In females, the ovaries were classified into immature, early maturing, late maturing, mature and spent-recovering stages based on the size, colour and yolk formation (Primacera, 1989). Specimens with immature, spent-recovering and early maturing ovaries were rated as immature while those with late maturing and mature ovaries were considered as matured ones. The gonads were cut open on the dorsal side and removed to observe its condition. The weight of gonad was taken by using electronic balance to the nearest 0.001 g. The gonads were preserved in 7% formalin for further analysis.

Sex ratio: The sex ratio is based on the monthly estimated number as to get an actual representation of males and females in the population. Homogeneity of the sex ratio (based on observed numbers) over months in three years has been tested using Chi-square test (Snedecor and Cochran, 1967). This is computed as follows:

$$X^2 = \sum (O-E)^2 / E$$

Where, O = observed number of males and females in each month/length group, and E = expected number of males and females in each month /length group. Significance at probability level of $P = 0.05$ was carried out. Homogeneity was tested for 1:1 ratio.

Length at first maturity (LM₅₀): Sex was determined and stages were classified as immature, early maturing, late maturing, mature and spent (Dall et al., 1990). The maturity classification was made (Farfante, 1969) where stages III and above were considered to be mature for males and females, respectively. For both males and females, the size at first maturity was determined by calculating the proportion of mature individuals in each size class (carapace length and total length). The size at which 50% of individuals were mature was taken as the length at first maturity (LM₅₀) (King, 1995).

Spawning season: To determine the spawning

season, proportion of the gravid and ripe females (IV and V) in each month were observed and the highest percentage were taken to determine the spawning period.

Gonado somatic Index (GSI): The spawning season of *P. monodon* was estimated from the mean index value of gonad in different months of the year. For gonado-somatic index (GSI) estimation, females were weighed individually after wiping it dry. The gonad was dissected out carefully and weighed by using an electronic balance. The GSI are calculated by using the formula:

$GSI = (\text{Weight of the gonad} \times 100) / \text{Weight of the fish.}$

Fecundity: For studying the fecundity, the preserved ovary was washed and dried by placing it between two blotting papers. The ovary sub-sample was taken from the anterior, middle and posterior regions of the ovary. The weight of ovary was recorded, and all sub-samples of the ovary were weighed to the nearest 0.001 g. using an electronic balance. The mature ova present in the sub-samples were counted by using a counting slide. From the number of ova in the weighed sub-sample, fecundity was calculated using the formula:

$\text{Fecundity} = (\text{total weight of the ovary/weight of the sample}) \times \text{number of ova in the sample}$

The relationship between the fecundity to total length, total weight and ovary weight were found out by fitting regression on logarithms of observed values by least square method (Snedecor and Cochran, 1967).

$$F = \alpha X^b$$

Where, F = Fecundity, α = constant, X = variable (total length, body weight or ovary weight) and b = correlation coefficient. The exponential relationship was transformed into a straight line logarithmic form based on the equation: $\text{Log } F = \text{log } \alpha + b \text{ log } X$.

Results

Sex ratio: During 2011-2013, total numbers of 631 specimens of *P. monodon* were examined, of them 242 were males, and 391 were females. The sex ratio is presented in Tables 1 and 2. The overall yearly sex

Table 1. Annual sex ratio of *P. monodon* during fishing period of 2011-2013.

Month	2011				2012				2013			
	Male	Female	d2/e	Sig	Male	Female	d2/e	Sig	Male	Female	d2/e	Sig
Jan	10	9	0.026	S	8	13	0.595	S				
Feb	14	9	0.543	S	9	11	0.1	S	11	16	0.463	S
Mar	6	7	0.038	S	6	15	1.929	S				
Apr	0	0	0	S	5	5	0					
Jun	3	14	3.559	S	5	21	4.923	NS	13	13	0	S
Jul	4	11	1.633	S	5	10	0.833	S	19	9	1.7857	S
Aug	3	19	5.818	NS	8	18	1.923	S	4	17	4.0238	NS
Sep	5	20	4.5	NS	11	13	0.083	S	6	13	1.2895	S
Oct	4	23	6.685	NS	13	8	0.595	S	11	9	0.1	S
Nov	4	12	2	S	7	21	3.5	S	19	5	4.0833	NS
Dec	4	21	5.78	NS	14	15	0.017	S	11	14	0.18	S

S=Significant, NS=Not significant

Table 2. Month-wise sex ratio of *P. monodon* during fishing period of 2011-2013.

Month	Male	Female	Total	chi square value	Significant	F/M
Jan	18	22	40	0.2	S	1.222222
Feb	34	36	70	0.028571	S	1.058824
Mar	12	22	34	1.470588	S	1.833333
Apr	5	5	10	0	S	1
Jun	21	48	69	5.282609	NS	2.285714
Jul	28	30	58	0.034483	S	1.071429
Aug	15	54	69	11.02174	NS	3.6
Sep	22	46	68	4.235294	NS	2.090909
Oct	28	40	68	1.058824	S	1.428571
Nov	30	38	68	0.470588	S	1.266667
Dec	29	50	79	2.791139	S	1.724138
Total	242	391	633	17.53633	NS	1.615702

S=Significant, NS=Not significant

ratio was observed to be 1:1.6 (males: females). A chi-square test showed that the annual distribution of females and males is not significantly difference from 1:1 ratio at 0.05% level ($P>0.05$), although the sex ratio varied from month to month during the study period.

Spawning season: Average gonadosomatic index of females of *P. monodon* is presented in Figure 1. In the present study, GSI was observed to be higher between January and July. The maximum value (GSI=10.36) was observed in June and minimum value (GSI=7.8) in October. The GSI of females of *P. monodon* showed two peaks, in the months of January and June. The highest GSI of 10.36 in June, indicating that most females were mature.

The percentage of mature females is presented in Figure 2. The highest mature percentage was observed in the month of February (88.89%) and June (85.4%). The lowest percentage was observed

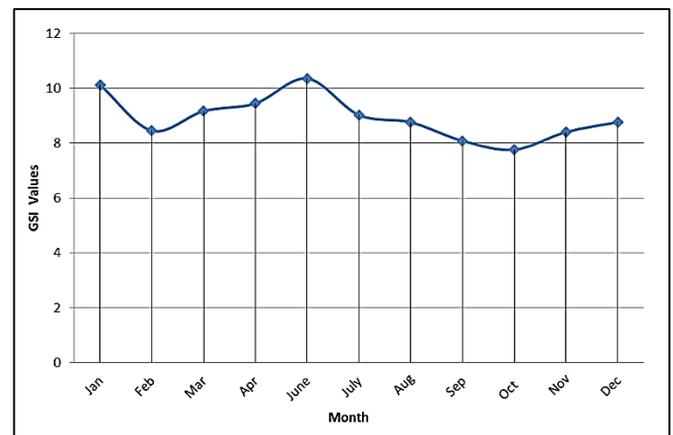


Figure 1. Average gonadosomatic index (GSI) of *P. monodon* females from Digha coast during 2011 – 2013.

in the month of September (65.2%). Mature females in all months were observed to be >50% indicating that *P. monodon* spawns more or less throughout the year.

LM 50: The length at first maturity is presented in Figure 3. In the present study, 163.5 mm was

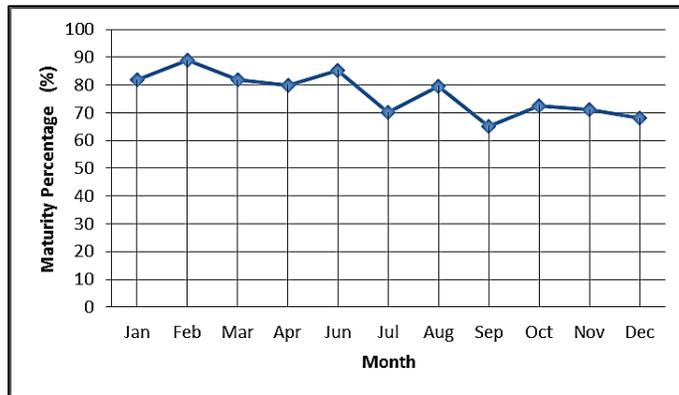


Figure 2. Average maturity percentage of *P. monodon* females from Digha coast during 2011-2013.

observed as the length at first maturity.

Fecundity: In the present study, length and weight of mature females of *P. monodon* ranged from 125-250 mm and 47-261 g, respectively. The estimated number of ova in the mature ovary ranged from 120155 to 961240 in ovary weight ranging 5 to 40 g. The relationship between fecundity and length and fecundity and weight of *P. monodon* was $\text{Log } F = 1.295461 + 3.135046 \text{ Log } L$ ($r = 0.607847$) and $\text{Log } F = 3.253808 + 1.022533 \text{ Log } W$ ($r = 0.58288$). There was significant variation ($P < 0.05$) in the slope of regression relations of body length and weight with fecundity.

Discussion

In the present study, the observed sex ratio was 1:1.6 (males: females). This could be attributed to changes in the fishing ground and fishing pattern of trawl nets and the pattern of migration during breeding seasons of both sexes. In general, sex ratio is known to be close to 1:1 (males: females) in nature (Fisher, 1958). Costa et al. (2010) suggested that the sex ratio of females may be related to the greater vulnerability of females to fishing due to their size. Sarada (2010) observed from Kozhikode, Kerala, India on the annual sex ratio between male and female to be 1.07:1.

Two peak spawning seasons were observed with the highest mature percentage of females in February and June. The results of GSI indicated the spawning season to be during January-February and June.

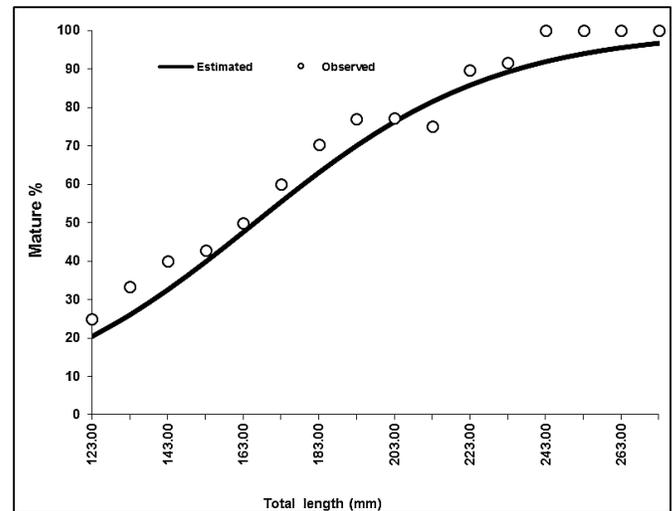


Figure 3. Length at first maturity (LM₅₀) of *P. monodon* females at Digha coast, India.

Similar results were reported by Khan et al. (2003) who observed the spawning season of *P. monodon* twice a year i.e. during winter (February) and summer (September). Along the Kakinada coast, the species spawns throughout the year with different peak periods in different years. Rao (2000) observed a similar phenomenon in the spawning off Visakhapatnam. Amanat and Qureshi (2011) observed the peak spawning activity from the coastal waters of Pakistan during August to October with a secondary peak during February to March. Shrimps exhibit more than one spawning period in a year. The process of ovarian maturation goes through different reproductive stages viz., undeveloped, developing, nearly ripe, ripe and spent. After completion of first spawning, shrimps rest in a developing stage before going through the maturation cycle again (Jayawardane et al., 2003).

The estimated number of ova in the mature ovary ranged from 120155 to 961240. Fecundity depends on the size of females. Babu (2014) observed the fecundity at 723251 for 270 g from Bhairavapalem (A.P) India, which slightly varies from the results of the present study. This may be due to differences of environment and on the availability of food. Fecundity increased with prawn size, suggesting that much of the available energy in larger prawns is devoted to egg production rather than growth. Motoh (1981) established a positive correlation between

fecundity and female size of *P. monodon* in terms of carapace length. Villegas et al. (1986) demonstrated a positive correlation between fecundity and spawner weight of *P. monodon*. Primavera (1989) stated that fecundity or number of eggs of *P. monodon* in a complete spawning averages 300000 (range: 100000-800000) for ablated females and 500000 (range: 200000-1 million) for wild spawners.

Length at first maturity was observed at 163.5 mm in the present investigation. The results differ from Rao (2000), who studied the reproduction and the spawning of *P. monodon* from Kakinada, possibly because of differences in food, temperature and water quality, impacting maturity. According to Rao (2000), the females attain maturity at 196-200 mm and males at 166-170 mm TL. Amanat and Qureshi (2011) estimated size at onset of sexual maturity at 13.33 cm from the lagoon water of Pakistan.

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چکیده فارسی

زیست‌شناسی تولیدمثل، اندازه بلوغ و نسبت جنسی میگوی ببری سیاه (*Penaeus monodon* Fabricius, 1798) در مناطق صیادی سواحل دیقا، بنگال غربی، هندوستان

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چکیده:

مقاله حاضر زیست‌شناسی تولیدمثل، اندازه بلوغ و نسبت جنسی *Penaeus monodon* صید شده از مناطق صیادی دیقا، هندوستان طی سال ۲۰۱۱ الی ۲۰۱۳ مطالعه می‌کند. تعداد ۶۳۳ نمونه *P. monodon* مورد بررسی قرار گرفت که از آن‌ها ۲۴۲ عدد نر و ۳۹۱ عدد ماده بودند. نسبت جنسی مشاهده شده در دوره مطالعه ۱ به ۱/۶ (نر به ماده) بود. براساس نتایج، فصل تخم‌ریزی *P. monodon* به‌طور عمده ماه‌های ژانویه و فوریه بود و تا ماه ژوئن نیز ادامه داشت. نخستین بلوغ در طول ۱۶۳/۵ میلی‌متری مشاهده شد. تعداد تخمینی تخم در تخمدان نمونه‌های بالغ در محدوده ۱۲۰۱۵۵ تا ۹۶۱۲۴۰ عدد بود.

کلمات کلیدی: LC₅₀، فصل تخم‌ریزی، GSI.