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STRUCTURE AND SEASONAL DYNAMICS OF THE JUVENILE BROWN SHRIMP, *METAPENAEUS MONOCEROS* IN THE SUNDARBANS MANGROVE WATERS, BANGLADESH

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ABSTRACT: The density and temporal distribution of the postlarvae and juveniles of *Metapenaeus monoceros* in the Sundarbans water were assessed for two years, along with the environmental factors. There is significant monthly variation in the abundance of *M. monoceros* ($P<0.05$) with the species most common during the post-monsoon season. The relationship between the water parameters and population structure of *M. monoceros* is discussed.

KEYWORDS: *Metapenaeus monoceros,* juveniles, postlarvae, Sundarbans, mangroves.

INTRODUCTION

The current view of the importance of mangrove is mainly based on the studies that show that the juveniles of many penaeid shrimp species are caught near such habitats. The extent of the mangroves is also closely associated with the size of offshore catches. Extensive studies have shown that juvenile penaeid shrimps are often highly abundant in mangrove habitats (Boonruang and Janekaru, 1985; Chong *et al.,* 1990). The brown shrimp, *Metapenaeus monoceros,* is an important component of the commercial catches of penaeid shrimps throughout the Bangladesh coast. The species accounts for about 55% of the total shrimp trawl catches in the Bay of Bengal and it appears to be unders some fishing pressure (Mustafa and Khan, 1993; Mustafa, 1996).

The Sundarbans is the single largest compact mangrove ecosystem in the world located in the Gangetic Delta and has been a World Heritage Site since 1999. Harvest of wild shrimp seed specifically *Penaeus monodon* and *Metapenaeus monocerous* along the coastal rivers of Bangladesh including the Sundarbans mangrove is widespread. The southwestern coastal belt is a major area for marine shrimp production and represents the country's third largest source of export income.

The aim of the present study was to examine the effects of season and environmental variables on the abundance and distribution of *M. monoceros* postlarvae and juvenile in the Sundarbans.

MATERIALS AND METHODS

Sampling sites and gear: The Sundarbans is located between longitude 89°00'E and 89°55'E and latitude 21°30'N and 22°30'N. Based on the salinity, zonation patten, intensive sampling was carried out in five river systems of the Sundarbans, located at about 40-50 km upstream from the Bay of Bengal estuary (Fig. 1). Passur, Sibsa and Koyra rivers are wholly freshwater, Kholpatua river is brackish and Madar river is in the saline zone. These rivers were sampled monthly for 2 years from June 2000 to May 2002. A rectangular drag net with a length of 2 m including cod end and a mesh size of 2 mm was used for sampling. The net at the opening, is made of a split bamboo structure ($1.6x0.6m^2$) and a plastic bucket was attached at the cod end for collecting samples, T-device is slightly modified from those widely used for wild *P. monodon* seed collection in coastal waters. A synthetic monofilament net material (high density polyethylene) with knotless webbing was used to make the sampling net. The net is comparable with sampling nets used by Mohan *et al.* (1995) and Rajendran and Kathiresan (1999).

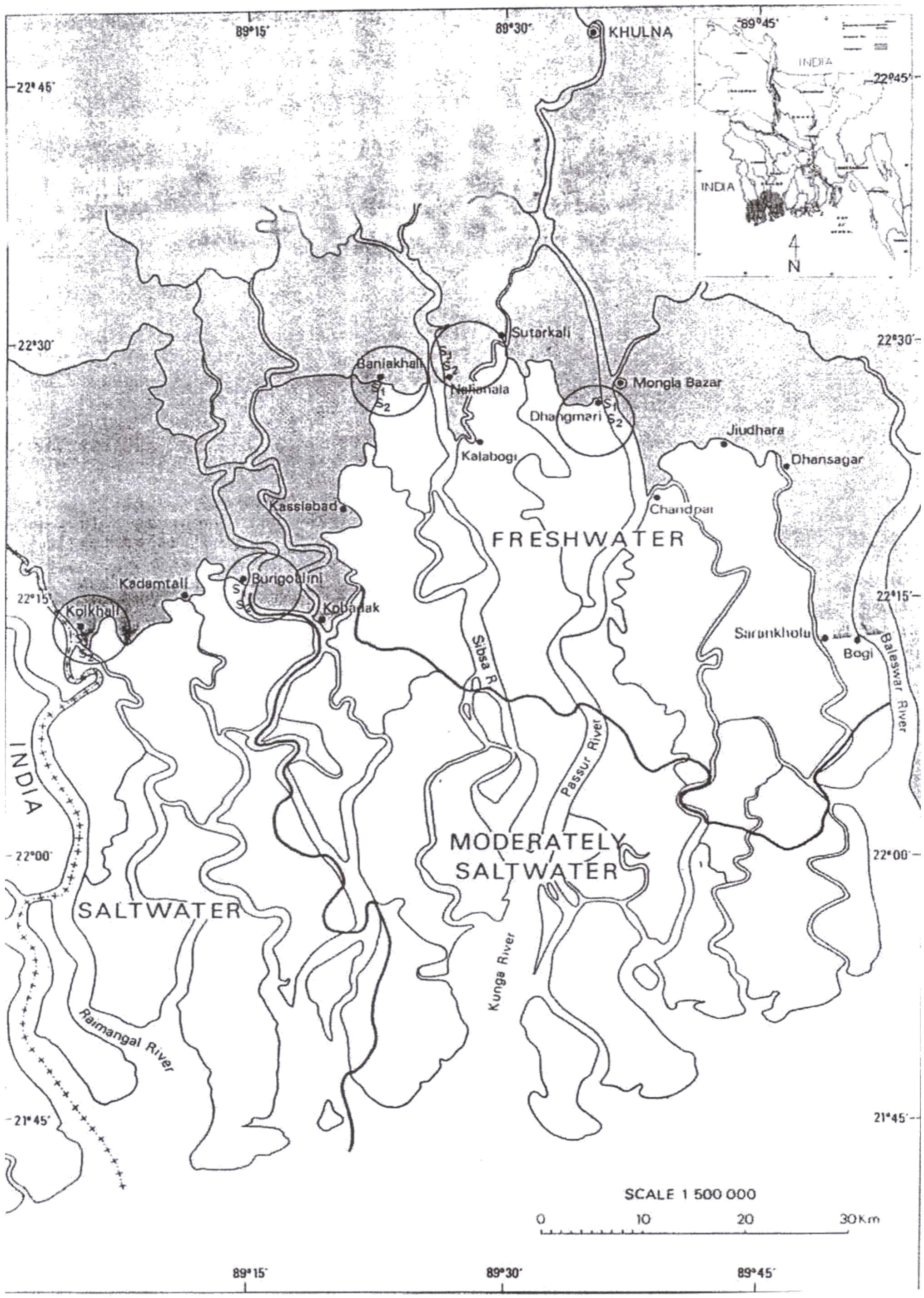

Fig 1. Study area and location of the sampling stations in 5 river systems of Sundarbans mangrove.

Monthly samples were collected during the day time at low spring tides (MH20 high tide) of full and new moons. Due to some practical and safety reasons, sampling was not possible at night in the Sundarbans. For each sampling, the net was dragged, starting from shallow waters and continued to the adjacent mud bank covering a total area of 10 m^2. The area of coverage was held relatively constant. Usually four (and rarely two depends on weather) replicate sampling with each net were done in each netting time. In each sampling site, a distance of 1 km was maintained for replicate sampling (i.e. for 4 netting 2 from one spot and another 2 towards about 1km from the first spot). On shore, the catches were cleaned of any twigs, leaves and specimens preserved with about 5 percent neutral formalin in river water.

In the laboratory, the number of all penaeid species was recorded and specimens of *M. monoceros* were identified following the description of CIFRI (1962) and Howlader (1976). The larvae and juveniles were counted and measured for total body length, in randomly selected individuals per sampling.

Water parameters: Water samples for the determination of physicochemical parameters were collected during the collection of specimens from the surface of each site by a clean bucket. Water transparency was measured with a standard Secchi disc of 20 cm diameter. The temperature of surface water, salinity, conductivity and total dissolved solids (TDS) were measured directly with a direct reading integrated conductivity meter (Jenway 4200 Conductivity Meter). The pH of the water was measured using a portable pH meter (pH Scan-2, sensitivity 0.1±0.02), which was calibrated with pH buffer, 4.0 and 7.0 before every use.

For Chlorophyll-*a* analysis, 500-1000 ml water from each samples from each sampling sites was filtered under vacuum (1/3 atmospheric pressure) through 45 mm Whatman micro-fibre filters. For field use a hand vacuum filter pump (Neward Enterprise, Model CUCAMONCA CA) was utilised. Chlorophyll-*a* was extracted in 90% acetone and estimated spectrophotomerically following the method described by Parsons *et al.* (1984). For each sampling station duplicate samples were analyzed.

Data analysis: In order to estimate the inter-annual density changes of the *M. monoceros*, the density coefficient of variation within each year ($C.V._w = 100S_m / \overline{X}_m$, where $\overline{X}_m$ and S_m are mean and standard deviation of monthly abundance, respectively) and among years ($C.V._a = 100S_a / \overline{X}_a$, where $\overline{X}_a$ and S_a are mean and standard deviation of annual abundance, respectively) were calculated. Two-way analysis of variance (ANOVA) with rivers and seasons as fixed factors, were used to compare the equality of mean numbers of shrimps per sampling. Statistical analysis was performed using the STATISTICA (5.5) and SPSS (10.0.1) software package.

RESULTS

Abundance and distribution: During the two years study in five rivers of the Sundarbans, a total of 13,013 shrimp individuals were collected. Among this 32.62% were penaeids and 67.38% were carideans. *M. monoceros* represented 49.12% of the total penaeid catch. The maximum total catch of *M. monoceros* individuals i.e (224/haul) was recorded in November 2000 in Khalpatua river. The monthly fluctuation of *M. monoceros* density in the different rivers are presented in Figure. 2. *M. monoceros* had the highest density in winter (Nov.-Jan.) during both sampling years. The mean total catch ranged from 2 to 18 individuals/haul in monsoon, 6 to 58/haul in the post-monsoon, 6 to 47/haul in winter and 2 to 7/haul in the pre-monsoon (Fig. 3). *M. monoceros* was more abundant in postmonsoon and winter periods, although the occurrence is not statistically significant.

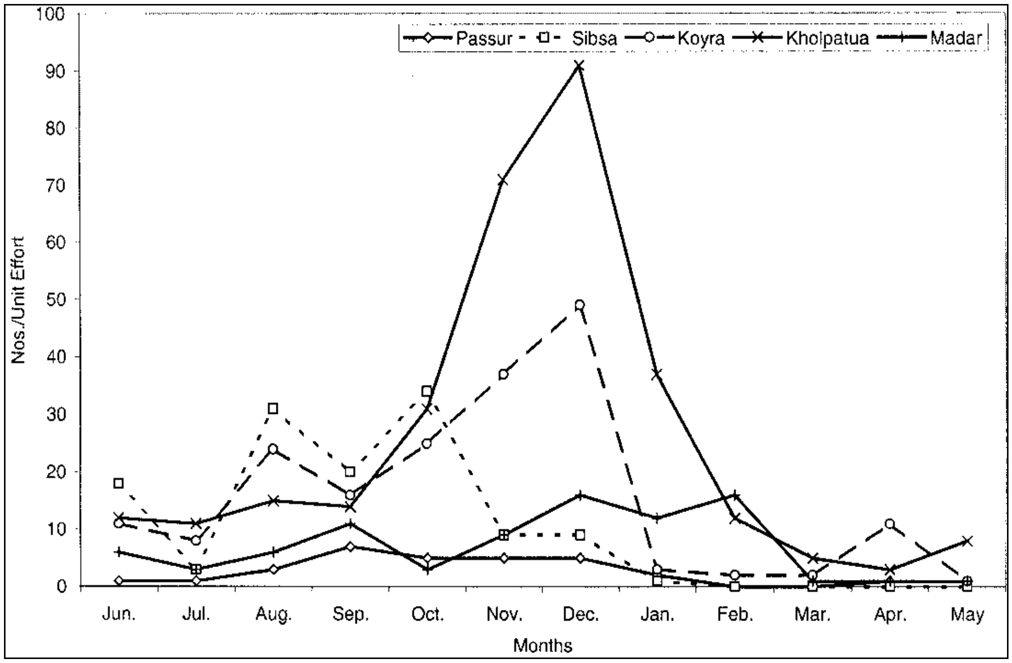

Fig 2. Monthly mean density of *Metapenaeus monoceros* in 5 river systems of Sundarbans

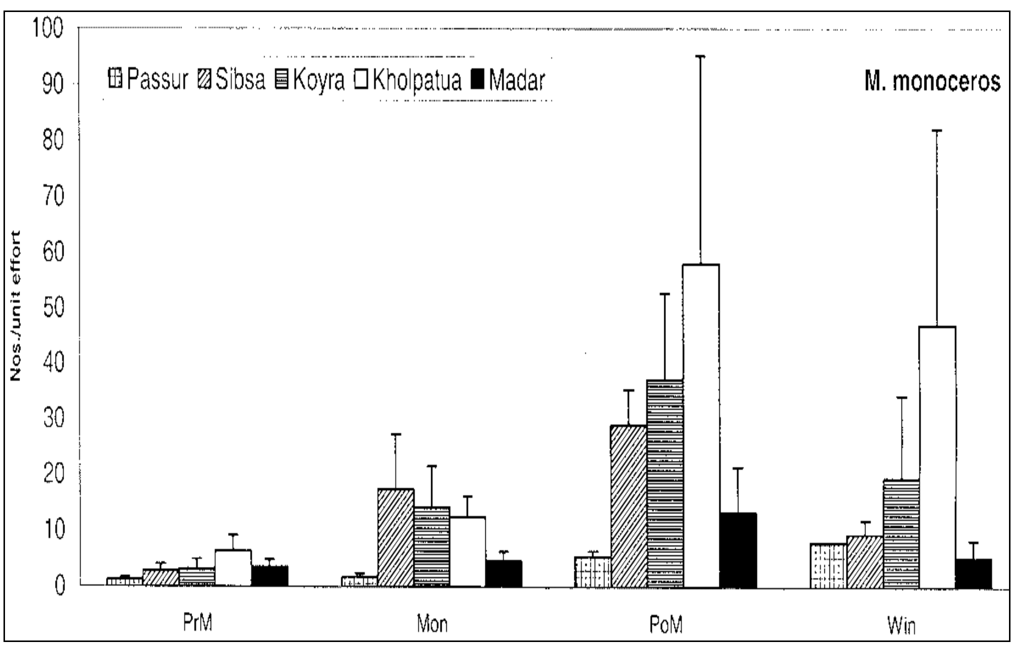

Fig. 3. Mean seasonal abundance (±SE) for *Metapenaeus monoceros* in rivers of Sundarbans. PrM, premonsoon; Mon, monsoon; Pom, post monsoon; Win, winter

Community structure: The postlarvae and juveniles of six species of Penaeidae *viz. Penaeus monodon, Fenneropenaeus indicus, Metapenaeus monoceros, M. brevicornis, Parapenaeopsis sculptilis* and *P. stylifera;* five species of Palaemonidae *viz. Macrobrachium rosenbergii, M. villosimanus, M. lamarrei, M. mirabilis* and *Exopalaemon styliferus* and *Acetes* spp. (Sergestidae) were recorded. The study revealed the predominance of *M. monoceros, M. brevicornis* and *Macrobrachium villosimanus* totaling 54.57% in the five rivers. These species were observed throughout the study period. Among total shrimp catch *M. monoceros* represented 16.02%, *M. monoceros* showed a higher variability during 2000-2001 than among years in Koyra, Kholpatua and Madar river ($C.V._w > C.V._a$) (Table 1).

Table 1. Time of first collection, mean density (D_w= nos./unit effort) and coefficient of variation ($C.V._w$= %) within each year, inter-annual mean density (D_a= nos./unit effort) and coefficient of variation ($C.V._a$= %) among years for the *Metapenaeus monoceros* in rivers of Sundarbans

Rivers	2000-2001			2001-2002			Among years	
	Month	D_w	$C.V._w$	Month	D_w	$C.V._w$	D_a	$C.V._a$
Passur	July	3.64	68.68	June	3.4	81.69	3.52	74.38
Sibsa	December	7.57	82.43	July	14.25	90.11	10.91	87.44
Koyra	June	23.06	158.24	July	17.92	100.17	20.49	132.85
Kholpatua	June	51.67	154	June	20.25	72.54	35.96	131.06
Madar	June	10.88	121.23	Jull:	3.5	64.86	7.19	107.51

The size of the penaeid postlarvae and juveniles abundance in the rivers of Sundarbans varied from species to species. The mean body length of penaeid shrimps was between 10-38 mm. Larger size *M. monoceros* were frequently abundant in all rivers. *M. monoceros* with >35mm were abundant in winter (Fig. 4).

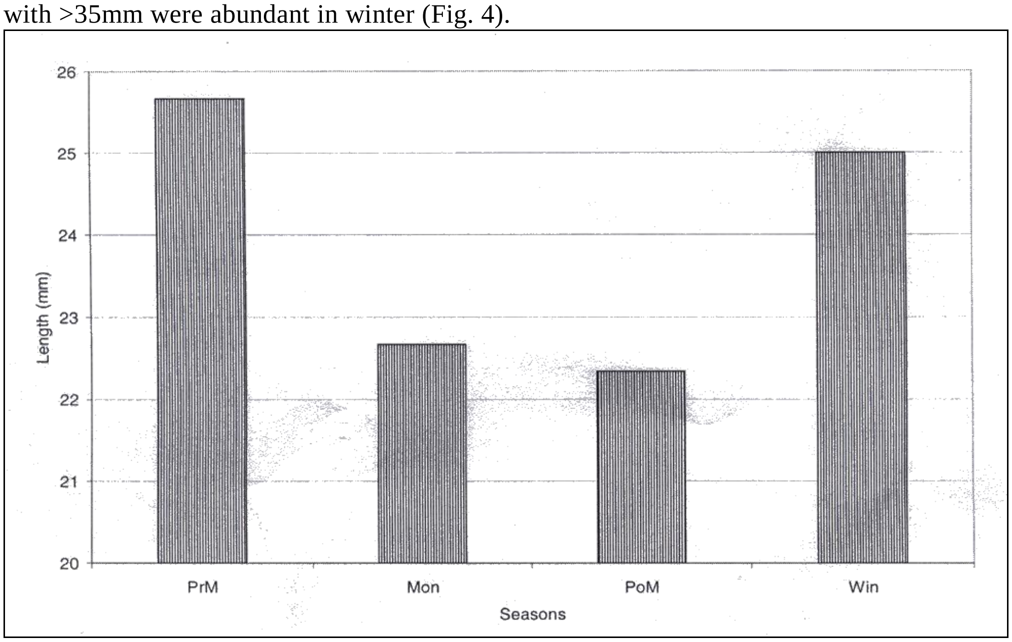

Fig. 4. Seasonal mean total length (TL) of *Metapenaeus monoceros* in Sundarbans. PrM, premonsoon; Mon, monsoon; PoM, post monsoon; Win, winter.

Table 2 shows the effect of season and site variation on the abundance of *M. monoceros*. *M. monoceros* significantly varied in monthly abundance ($p<0.05$).

Table 2. ANOVA for the effects of year, month, site and interaction on numerical abundance of *Metapenaeus monoceros* in the Sundarbans from June 2000 through May 2002 (df = degree of freedom, SS = sum of squares, MS = SS/df, F = MS among/MS within.

Source	df	SS	*F* value
Year	1	58.5	0.29
Month	11	8355	**3.81***
River	4	13363.05	4.99
Year x Month	11	14618.83	3.4*
Year x River	4	6244.18	3.99
Month x River	44	37782.9	**2.45***

*= $p<0.05$

Abundance in relation to water parameters: The abundance of *M. monoceros* during the 2 years study was found to correlate with the water parameters which are presented in Table 3. It was observed from the table that abundance of *M. monoceros* was not significantly correlated with water parameters in the studied years. *M. monoceros* was negatively correlated with salinity, conductivity and TDS in both the years.

In order to find out more specific correlation between the water quality and the abundance of *M. monoceros,* a multiple correlation was done and the results are presented in Table 4. Although correlation patterns differed for the 2 years, a positive correlation existed with temperature, pH, transparency, conductivity and TDS in the first year, and salinity, pH and chlorophyll-*a* in the second year.

Table 3. Correlation coefficient between biotic and abiotic factors.

Year	Temperature	Salinity	pH	Transparency	Conductivity	TDS	Chlorophyll-a
2000-2001	-0.01	-0.29	0.09	0.3	-0.27	-0.27	-0.01
2001-2002	0.06	-0.08	0.11	-0.23	-0.14	-0.17	0.03

DISCUSSION

The Sundarbans is an unusual mangrove ecosystem. The forest is flushed year-round with upland river water, and general salinity remains relatively low. The dominant plant, *Heritiera jomes*, a species practically unknown in mangrove forests elsewhere in the world is unusual as it does not posses any adaptive tolerance to high salinity. Juvenile penaeid shrimps occurred abundantly throughout the year with varying size groups in different seasons. *M. monoceros* was common throughout the year in Sundarbans. Monthly variation in density of *M. monoceros* abundance was broadly similar among rivers. Significant inter-month variation in abundance of *M. monoceros* was observed from the present study. Inter-month significant variation was also observed by George *et al.* (1998) for *M. monoceros.* In Sundarbans, a major peak of penaeids occurred from October through January, which indicated seasonal spawning. The spawning of penaeid shrimp mainly takes place in the offshore waters during post-monsoon, after a short larval life of 2-3 weeks, with the postlarvae migrating to the mangroves for their development (Staples and Vance, 1985).

Metapenaeus monoceros was the dominant penaeid shrimp in Pilerne mangrove, Goa, India and it grows in the mangroves for 7-8 months (Achuthankutty *et al.*, 1980). Penaeid shrimps were reported to be abundant during premonsoon in mangrove water of Goa, India with predominantly *M. dobsoni, M. monoceros and Fenneroponaeus merguiensis*. Year round recruitment took place only in *M monoceros* (Achuthankutty and Nair, 1982). Immigration of penaeid postlarvae takes place throughout the year in Satkhira estuary (Sundarbans) with peak abundance during monsoon and minimum in premonsoon. The penaeid postlarvae were dominated by *M. monoceros* (51.05%), *P. monodon* (14.75%) and *M. brevicornis* (3.02%) (Mahmood and Zafar, 1990). In the present study, major peak of penaeid postlarvae was in winter and lean period was in premonsoon. Here *M. monoceros* was also dominated (18.26-44.21%) followed by *M. brevicornis* (8.12-19.62%) but abundance of *P. monodon* largely reduced (0.78-2.1%). Furthermore, Mahmood and Zafar (1995) recorded 64.1% penaeids and 35.9% carideans with major peak during postmonsoon and lean during winter in the Satkhira estuary, whilst finding of the present study was 28.44% penaeids and 45.86% carideans, rest was crab megalopae. Although juveniles of the various shrimp species were seasonal in occurrence, penaeid postlarvae as a whole were relatively abundant throughout the year in Sundarbans water. Thus there is apparently little spatial or temporal correlation between recruitment of other species of shrimps. Maximum number of juveniles was recorded during the postmonsoon period. Their abundance declined during the premonsoon and continued through the monsoon. Similar to present study, eight species of penaeid shrimps were recorded with *M. monoceros* and *M. brevicornis* as dominant species in all seasons at Pichavaram mangrove, India (Rajendran and Kathiresan, 1999).

Abundance of *M. monoceros* was positively correlated to most of the water parameters (Table 4). Environmental factors are only one aspect that determines the occurrence of juvenile shrimp and fish in the mangroves. Biological factors such as population characteristics and predation would further affect the occurrence of juveniles in the mangrove. Several species of penaeids have been found to be transported into estuaries on the flood tide (Wickens, 1976) and a number of hypotheses concerning the mechanism by which larvae are carried from the off-shore spawning areas into the estuaries have been suggested. The apparent disagreement among different workers as to how larvae are transported into an estuary appears to arise from having insufficient data for both the biology of the larvae and the prevailing hydrological conditions in the area in which a particular species is being studied.

Table 4. Multiple regression equation for the numbers of *Metapenaeus monoceros* caught in Sundarbans river versus water quality during 2000-2002.

Multiple regression equations	R^2	P
Y= -254.26+0.89Tem23.93Sal+19.82pH+5.24Tra+2.21Con+20.81TDS-2.69Cho	0.3	0.29
Y= 94.58-2.22Tem+1.67Sal+0.99pH-2.2Tra-0.23Con-1.36TDS+0.47Cho	0.16	0.25

R^2=Multiple regression coefficient, P = Probability, Tem = Temperature, Sal = Salinity, Tra = Transparency, Con = Conductivity, TDS = Total dissolved solids, Cho = Chlorophyll-*a*

In mangrove environment, the extensive intertidal zone in the river bank is shallow and located at some distance from deep water where juveniles are unable to move quickly from the mud bank to the deeper mid-river during low tide. The twice-yearly recruitment of penaeid juveniles in many mangrove habitats is common (Vance *et al., 1990;* Primavera, 1998). This pattern can be traced to the occurrence of two spawning peaks among many tropical *Penaeus* and *Metapenaeus* spp. (Dall *et al.,* 1990) during the intermonsoon months of September-November and March-April which are characterized by decreased winds and currents (Staples, 1991). *M. monoceros* is a continuous breeder with two major spawning periods during December-April and August-September (Nandakumar, 2001). No distinct recruitment pattern of *M. monoceros* postlarvae was identified in the present study, although peak abundance of *M. monoceros* was recorded during October to January (postmonsoon and winter). The pattern of twice yearly juvenile recruitment to the mangrove sites seems coinciding with warm water temperature and moderate salinity. The mangroves being a storage area when they are inundated, prawn larvae remain trapped in the mangroves by the lateral trapping effect. Inundation is more frequent at spring tides than at neap tides, and this resulted in a significantly larger trapping at spring tides than at neap tides (Chong *et al.*, 1996). The gradual fall in water level with the onset of low tide results in the subsequent exposure of the submerged area and thus the area available for the settlement of shrimp seed gets reduced. This reduction in the area for distribution might have resulted in the maximum occurrence of seed at the time of low tide.

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