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Seasonal dynamics of the juvenile brown shrimp, *Metapenaeus monoceros* (Fabricius) in the Sundarban mangrove waters, Bangladesh

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ABSTRACT

The density and temporal distribution of postlarvae and juveniles of *Metapenaeus monoceros* in the waters of Sundarbans were assessed for two years, along with environmental factors. *M. monoceros* represented significant ($P<0.05$) monthly variation in abundance. Abundance of *M. monoceros* in the sundarban river systems was largely confined to the post-monsoon season. The relationship between the water parameters and population structure of *M. monoceros* has also been discussed.

Introduction

Extensive studies have shown that juvenile penaeid shrimps are often highly abundant in mangrove habitats (Boonruang and Janekaru, 1985; Chong *et al*., 1990). Brown shrimp, *Metapenaeus monoceros* is an important component of the commercial catches of penaeid shrimps throughout the Bangladesh coast. This species accounts for about 55% of total shrimp trawl catch in the Bay of Bengal and its fishery appears to be under fishing pressure (Mustafa and Khan, 1993; Mustafa, 1996).

The Sundarbans is the largest single compact mangrove ecosystem in the world located in the Gangetic delta and is considered as a 'World Heritage Site' since 1999. Harvest of wild shrimp seeds specifically of *Penaeus monodon* and *M. monoceros* is a common practice in coastal rivers of Bangladesh including Sundarban mangrove areas.

The aim of the present study was to examine the effects of season and environmental variables on the abundance and distribution of post larvae and juveniles of *M. monoceros* in the Sundarban waters.

Materials and methods

Sampling sites and gear

The Sundarbans is located between longitudes 89°00'E and 89°55'E and latitudes 21°30'N and 22º30'N. Based on salinity and ecological zonation, 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 represent freshwater, Kholpatua river represents semi-saline and Madar river forms 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 was made of bamboo spilt structure (1.6×0.6 m^2) at the opening and a plastic bucket was attached at the cod end for collecting samples, which 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

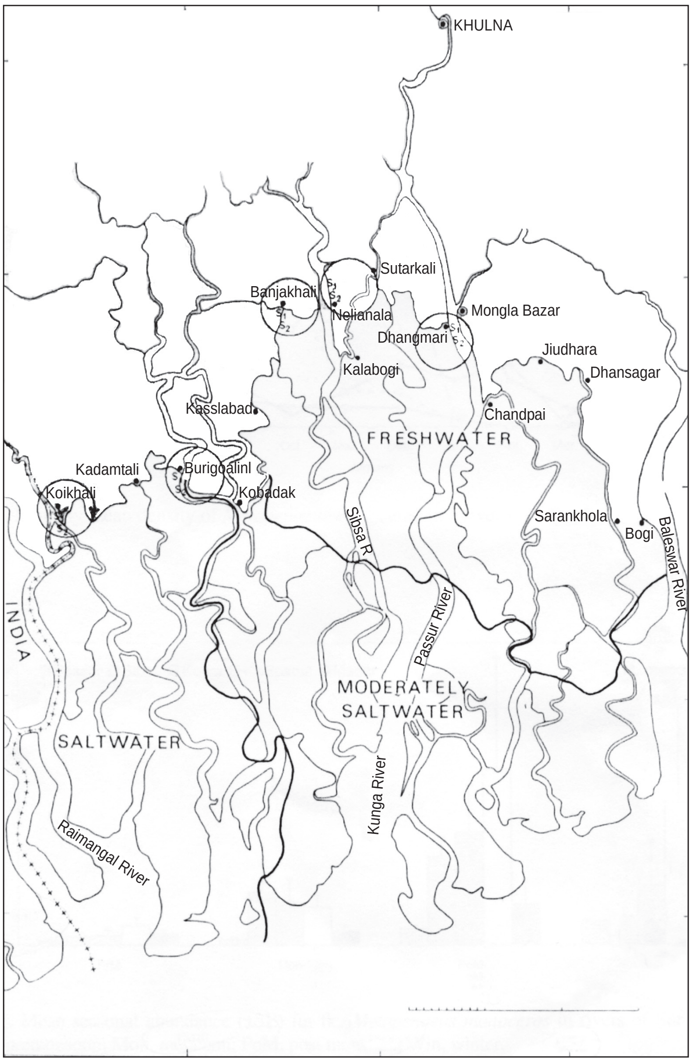

Fig. 1. Study area and location of the sampling stations in 5 river systems of Sundarban mangrove area

by Mohan *et al*. (1995) and Rajendran and Kathiresan (1999).

Monthly samples were collected at day time during spring low tides (MH20 high tide) of full and new moon period. 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 relatively constant. Usually four (and rarely two depending on weather) replicates were done in each netting time. In each sampling site, a distance of 1 km was maintained for replicate sampling. The catches were cleaned of twigs, leaves, large specimens and preserved with about 5% neutral formalin in river water.

In the laboratory, the number of all penaeid species was recorded and specimens of *M. monoceros* were identified from the description of CIFRI (1962) and Howlader

(1976). The larvae and juveniles were counted and measured for total body length, in randomly selected individuals of each sampling.

Water quality parameters

Water samples for the determination of physicochemical parameters were collected from the surface of sampling site using 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). Water pH was measured using a portable pH meter (pH Scan-2, sensitivity 0.1 ± 0.02).

For Chlorophyll-a analysis, 500-1000 ml water sample from each sampling site was filtered under vacuum (1/3 atmospheric pressure) through 45 mm Whatman microfibre filters. For field use, a hand vacuum filter pump (Neward Enterprise, Model CUCAMONCA CA) was used. Chlorophyll-a was then extracted in 90% acetone and estimated spectrophotometrically 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 *M. monoceros*, the density coefficient of variation within each year ($C.V._w = 100S_m / X_m$, where X_m and S_m are mean and standard deviation of monthly abundance, respectively) and among years ($C.V._a = 100S_a / X_a$, where X_a and S_a are mean 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 shrimp per sampling.

Statistical analyses were performed using the STATISTICA (5.5) and SPSS (10.0.1) software packages.

Results

Abundance and distribution

During the two years study in 5 rivers of Sundarbans, a total of 13,013 shrimps were collected. Among this, 32.62% was recorded as penaeids and 67.38% as carideans. *M. monoceros* represented 49.12% of total penaeid catch. The maximum total catch of *M. monoceros* was recorded in November 2000 in Khalpatua river. The monthly fluctuation of *M. monoceros* density in different rivers are presented in Fig. 2. The density of *M. monoceros* was maximum in winter (November-January) during both the sampling years. The mean total catch ranged from 2 to 18 individuals / haul in monsoon, 6 to 58 / haul in postmonsoon, 6 to 47 / haul in winter and 2 to 7 / haul in premonsoon months (Fig. 3). *M. monoceros* was more abundant in postmonsoon and winter months. However, the

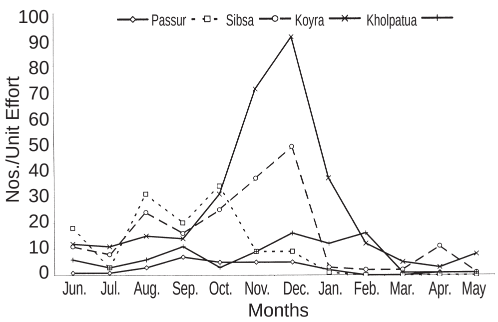

Fig. 2. Monthly mean density of *M. monoceros* in 5 river systems of Sundarbans

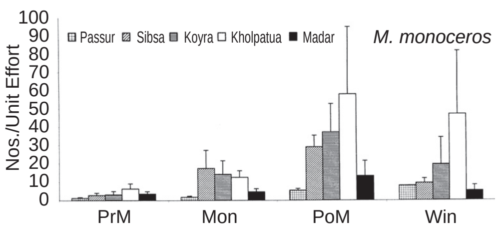

Fig. 3. Mean seasonal abundance (±SE) for *M. monoceros* in rivers of Sundarbans. PrM: premonsoon; Mon: monsoon; PoM: postmonsoon; Win: winter

difference in abundance was not statistically significant.

Community structure

The postlarvae and juveniles of 6 species of Penaeidae *viz. Penaeus monodon, Fenneropenaeus indicus, Metapenaeus monoceros, M. brevicornis, Parapenaeopsis sculptilis* and *P. stylifera*; 5 species of Palaemonidae *viz. Macrobrachium rosenbergii, M. villosimanus, M. lamarrei, M. mirabilis* and *Palaemon styliferus* and *Acetes* spp. of Sergestidae were recorded. The study revealed the predominance of *M. monoceros, M. brevicornis* and *Macrobrachium villosimanus* totaling 54.57% in 5 rivers of Sundarbans. These species were observed throughout the study period. Among the total shrimp catch, *M. monoceros* represented 16.02%. *M. monoceros* showed higher variability during 2000-2001 than among years in Koyra, Kholpatua and Madar rivers ($C.V._w > C.V._a$) (Table 1).

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

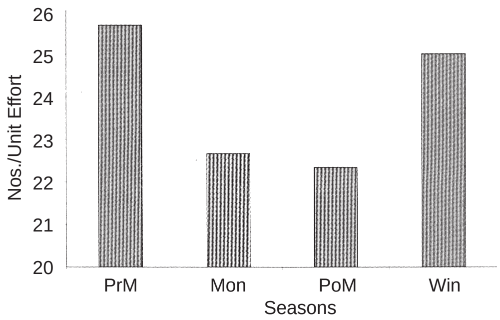

Fig. 4. Seasonal mean total length (TL) of *M. monoceros* in rivers of Sundarbans. PrM: premonsoon; Mon: monsoon; PoM: post monsoon; Win: winter.

Statistical analysis (ANOVA) to test the effect of year, month, site and their interaction showed that the monthly abundance of *M. monoceros* varies significantly ($p < 0.05$).

Abundance in relation to water quality parameters

During the study period, the abundance of *M. monoceros* did not show any significant correlation with water quality parameters. However, the abundance has shown negative correlation with salinity, conductivity and TDS in both the years (Table 2).

In order to find out more specific correlation between the water quality and the abundance of *M. monoceros*, a multiple

TABLE 1: *Time of first collection. mean density (D_w = nos./unit effort) and coefficient of variation ($C.V._w$ = %) within each year, and inter-annual mean density (D_a = nos./unit effort) and coefficient of variation (C.V.a = %) among years for* 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
Mardar	June	10.88	121.23	July	3.5	64.86	7.19	107.51

TABLE 2: *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

TABLE 3: *Multiple regression equation for the numbers of* M. monoceros *caught in Sundarban rivers versus water quality during 2000-2002*

Multiple regression equations	R^2	P
Y = –254.26 + 0.89Tem – 23.93Sal + 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 dissolve solids, Cho = Chlorophyll-a

correlation was done and the results are given in Table 3. Although correlation pattern differs between 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.

Discussion

The Sundarbans is a unique mangrove ecosystem. The forest is flushed year-round with upland river water, and salinity remains relatively low. Juvenile penaeid shrimps occurred abundantly throughout the year in varying size groups during different seasons. *M. monoceros* was predominant throughout the year. Monthly variation in density of *M. monoceros* abundance was similar among rivers. Significant inter-month variation in abundance of *M. monoceros* was observed during the present study. Significant inter-month variation was also observed by George *et al.* (1998) for *M. monoceros*. In Sundarban waters, major peak of penaeids occurred from October through January, which indicated seasonal spawning. The spawning of penaeid shrimp mainly takes place in the offshore during postmonsoon; after a short larval life of 2-3 weeks, the post larvae migrate to the mangrove waters for further development (Staples and Vance, 1985).

M. monoceros was the dominant penaeid shrimp for 7-8 months in Pilerne mangrove, Goa, India. (Achuthankutty and Nair, 1980). Penaeid shrimps were reported to be abundant during premonsoon in mangrove waters of Goa, India with *Metapenaeus dobsoni*, *M. monoceros and Penaeus merguiensis* predominating. Year round recruitment takes place only in the case of *M. monoceros* (Achuthankutty and Nair, 1982). Immigration of penaeid post larvae takes place throughout the year in Satkhira estuary (Sundarbans) with peak abundance during monsoon and minimum in premonsoon. The penaeid post larvae was 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 post larvae was in winter and lean period was in premonsoon. *M. monoceros* dominated (18.26-44.21%) followed by *M. brevicornis* (8.12-19.62%), but abundance of *P. monodon* was less (0.78-2.1%). Furthermore, Mahmood and Zafar (1995) recorded 64.1% penaeids and 35.9% carideans with major peak during postmonsoon and lean season during winter in the Satkhira estuary. The present study recorded 28.44% penaeids and 45.86% carideans, the rest being crab megalopa. Although juveniles of the various shrimp species were seasonal in occurrence, penaeid post larvae as a whole were abundant throughout the year in Sundarban waters. Thus, there was 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 the present study, 8 species of penaeid shrimps were recorded with *M. monoceros* and *M. brecvicornis* 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 quality parameters (Table 3). 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.

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 to the deeper mid-river during low tide. Two recruitments per year is common for penaeid juveniles in many mangrove habitats (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 this species was recorded during October to January (postmonsoon and winter). The pattern of juvenile recruitment to the mangrove sites coincide 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 (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 seeds get 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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