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Composition and Seasonal Dynamics of the Postlarval and Juvenile Shellfishes in the Sundarbans Mangrove Waters, Bangladesh

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Abstract

The composition and temporal distribution of the postlarvae and juvenile shellfishes in five rivers of Sundarbans with different salinity zones were studied, taking monthly or fortnightly day time samples using a drag net (2 mm mesh). Fifteen species belonging to six families of shellfish were recorded during two years of study. Four species of shrimp (*Metapenaeus monoceros*, *M. brevicornis*, *Macrobrachium villosimanus* and *Acetes* spp.) and megalopa of crab (*Scylla serrata*) were most abundant (79.3-96.83%). Megalopa of crabs were most numerous, making up to 25.6% of the total monthly catch, followed by *M. villosimanus* (21.19%), *Acetes* spp. (16.72%) and *M. monoceros* (14.38%). No significant seasonal or lunar variation in abundance of shellfishes was observed, although major annual peak in winter for shrimp and in monsoon for crab megalopa were recorded. When individual species was recorded, only *M. monoceros* represented significant ($P<0.05$) monthly variation in abundance. Abundance of *Penaeus monodon* significantly ($P<0.05$) varied with month and between five rivers, although annual variation was not significant. When compared with previous catch statistics (1992-93 and 1995-96), a declining trend in

P. monodon PL abundance was observed during 1995-96 and 1998-99, which was slightly increased in 1999-2000 period.

Introduction

The Sundarbans is the largest single compact mangrove ecosystem in the world located in the Gangetic Delta and termed as a World Heritage Site in 1999. Harvest of wild shrimp seed specifically *Penaeus monodon* is a very common practice in coastal rivers including Sundarbans mangrove of Bangladesh. Moreover, south-west coastal belt represent remarkable position in terms of land use and productivity in *P. monodon* production, which is the country's third largest export earner. The increasing demand for the PL of *P. monodon* during stocking time, and the simple technique of its collection allured a good number of people of the Sundarbans to earn their livelihood through collection of PLs from the estuarine region. About 181.4 million seeds of shell- and finfish considering undersized variety are being destroyed during *P. monodon* seed collection in West Bengal Sundarbans (Bhaumik et al. 1993), however, the same trend is also exhibited in Bangladesh Sundarbans. All previous studies were confined in coastal rivers with little attention on mangrove habitats (Mahmood and Zafar 1990, BOBP 1993, Islam et al. 1995). Despite many studies along Indian coast (Basu and Pakrasi 1979, Basu et al. 1998), little information is available on the Bangladesh Sundarbans.

The current view on the importance of mangrove is mainly based on the studies that have shown that the juveniles of many shrimp and of fish are caught near mangrove habitats and related the size of offshore catches to the extent of mangrove habitat. Extensive studies have shown that juvenile shrimps are often highly abundant in mangrove habitats (Boonruang and Janekaru 1985, Chong et al. 1990). However, nursery role of mangroves has also been demonstrated by studies that compare shrimp populations in mangroves and other habitats (Robertson and Duke 1987, Chong et al. 1990). The aim of the present paper is to document the structure and distribution of shellfish postlarval and juveniles and to some extent the loss of biodiversity by wild *P. monodon* PL collection in Sundarbans 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 22°30'N. Based on salinity 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 form the saline zone. These rivers had been sampled monthly for two years from June 1998 to May 2000. Fortnightly samples were also collected for a period to record the lunar cycle differences. 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 made of bamboo spilt structure (1.6x0.6m^2) 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 by Mohan et al. (1995) and Rajendran and Kathiresan (1999).

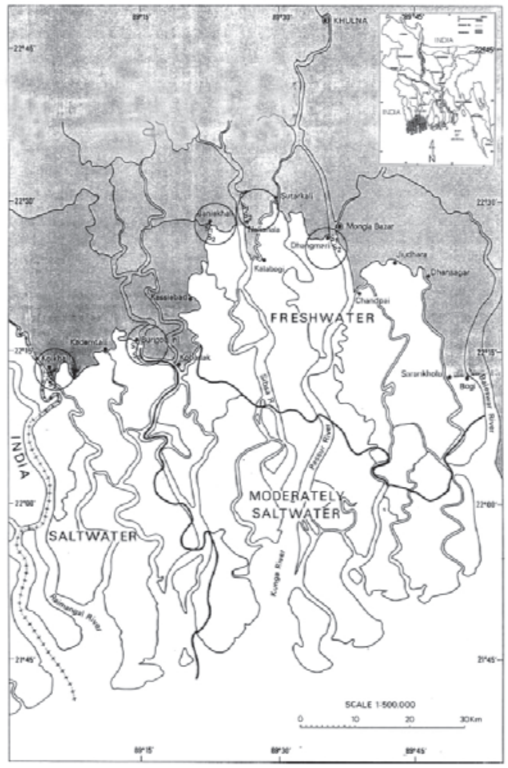


Fig. 1. Study area and location of the sampling stations in 5 river systems of Sundarbans mangrove

Samples were collected at day time during spring low tides (MH20 high tide) of full and new moons. Due to some practical grounds sampling was not possible at night in Sundarbans water. 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 nettings 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 1 km from the first spot). On shore, the catches were cleaned of any twigs, leaves, large specimens and preserved with about 5% neutral formalin in river water.

The larvae and juveniles were counted and measured for total body length, in randomly selected individuals per sampling. Individual species were then identified using a dissecting microscope (Olympus SZ-60, Japan). Identification was based on morphometrics, meristics, pigmentation and specialized larval characters (CIFRI 1962, Howlader 1976, Rajyalakshmi 1977, CMFRI 1978). Identification was made up to the species level.

Water parameters

Water temperature and salinity were determined during collection of samples in new and full moons from the surface of each sampling sites. The temperature and salinity were measured directly using a direct reading integrated conductivity meter (Jenway 4200 Conductivity Meter).

Data analysis

In order to estimate the inter-annual density changes of the most abundant species, the density coefficient of variation within each year ($C.V._w = 100S_m/\bar{X}_m$, where X_m and S_m are mean and standard deviation of monthly abundance, respectively) and among years ($C.V._a = 100S_a/\bar{X}_a$, where $\bar{X}_a$ and S_a are mean and standard deviation of annual abundance, respectively) were calculated. Two-way analysis of variance (ANOVA) with habitat (rivers) and times (seasons and lunar cycles) as fixed factors, were used to compare the equality of mean numbers of shellfish per sampling.

To compare the community changes of the most abundant species over time, samples were classified using the agglomerate cluster program, based on root-root transformed abundance data, together with the Bray-Curtis analysis of similarity, recommended by Field et al. (1982). Statistical analysis was performed using the STATISTICA (5.5) and SPSS (10.0.1) software package.

Results

Abundance and distribution

During two years study in five rivers of Sundarbans, a total 24,994 shellfish individuals were collected. In addition >20,000 mysids were also caught during sampling, although study was restricted to shellfish species. In the present study, 15 species belonging to six families of shellfish were identified (Table 1). Among these four species of shrimp, and 1 species of crab are commercially important.

The maximum average total catch of 511 individuals/haul was recorded in November'98 and 351/haul in January 2000. The monthly fluctuation of mean density of shrimp and crab megalopa are presented in figure 2. Shrimp was in maximum density during winter (Dec.-Feb.) in both the sampling years, whereas a major peak of crab megalopa was also recorded in winter for both years and in monsoon (Jun.-Aug.) during the second year. Monthly abundance of shrimp species were more variable than crab megalopa. The mean total catch ranged from 27 to 421 individuals/haul in monsoon, 77 to 511/haul in postmonsoon, 87 to 351/haul in winter and 75

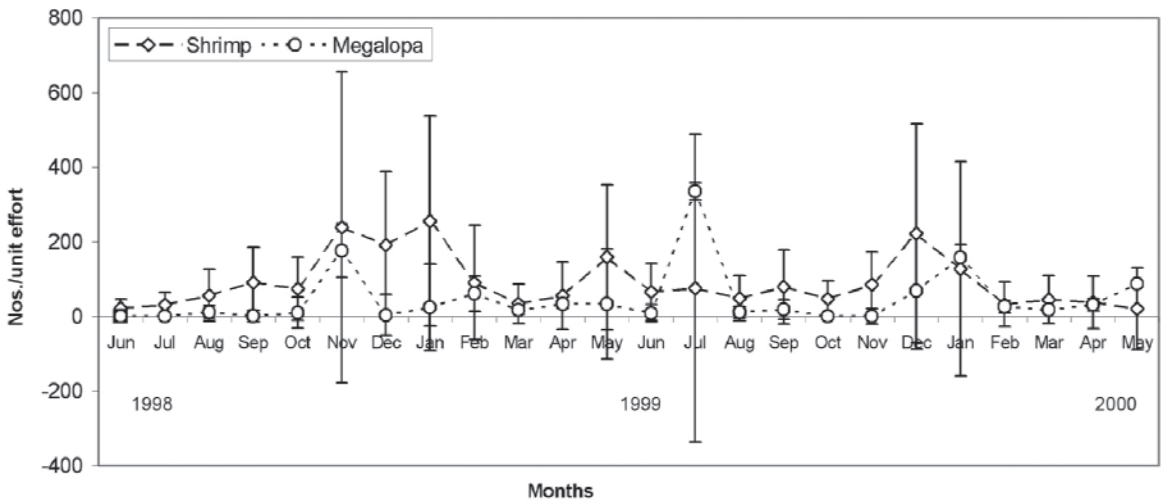
Table 1. Summarized data for the postlarvae and juvenile shellfish composition in five rivers of Sundarbans, indicating the % abundance in two years

Family Genus/Species	Passur river		Sibsa river		Koyra river		Kholpatua river		Madar river	
	1998-99	1999-2000	1998-99	1999- 2000	1998-99	1999-2000	1998-99	1999-2000	1998-99	1999-2000
Penaeidae *Penaeus monodon**	0.24	0.56	0.34	0.66	0.29	1.37	0.97	1.49	2.1	0.78
P. Indicus	0.03	0.04	0.14	0.12	0.07	0.26	0.17	0.4	0.52	0.23
*Metapenaeus monoceros**	1.08	0.63	3.65	17.88	13.27	18.36	44.21	24.02	18.26	1.09
M. brevicornis	2.03	1.41	4.19	24.04	2.78	12.72	16.83	8.12	19.62	1.55
Parapenaeopsis sculptilis	0.97	6.47	5.91	0.44	1.06	0.51	0.86	12.28	2.52	5.91
P. stylifera	1.11	0.22	0.14	-	-	-	0.46	0.5	1.16	0.35
Palaemonidae *Macrobrachium rosenbergii**	2.08	3.94	0.34	3.07	0.47	0.26	0.91	0.3	1.26	2.22
M. villosimanus	27.36	9.34	51.65	10.75	24.79	16.05	25.78	12.28	16.58	3.11
M. lamarrei	5.35	4.72	4.19	0.12	0.26	-	0.46	0.4	3.88	0.27
M. mirabilis	2.57	8.22	7.57	0.22	0.26	-	1.2	0.1	5.35	1.55
Palaemon styliferus	7.29	1.67	1.73	0.12	0.8	-	0.74	-	1.57	-
Sergestidae *Acetes* spp.	31.98	7.22	7.84	7.67	14.32	10.08	3.19	4.06	19.1	33.42
Alpheidae *Alpheaus euphrosyne*	0.35	0.33	-	0.55	-	0.26	-	0.10	-	0.04
Portunidae *Scylla serrata* (megalopa)*	17.02	54.16	11.97	32.6	41.11	39.62	3.65	35.15	7.93	49.13
Ocypodidae *Neptunus pelagicus* (‘’)	0.06	1.07	0.34	1.76	0.52	3.43	0.06	0.9	0.1	0.12
Unidentified	0.48	-	-	-	-	0.51	0.51	0.71	0.05	0.35

* commercial species

to 218/haul in premonsoon (Fig. 2). A maximum of 12 species of shellfish during May in Passur river was recorded. Although the number of shellfish species varied within and among years in the rivers of Sundarbans, species richness were highly variable. Maximum number of shellfish species were recorded during premonsoon period (March-May). Mysids were numerous during monsoon and winter, and highly abundant in Passur river.

Fig. 2. Monthly distribution of average numbers (±SE) of shrimp and crab megalopa in five river systems of Sundarbans during 1998 to 2000.



Community structure

The postlarvae and juveniles of six species of Penaeidae *viz*. *Penaeus monodon*, *P. indicus*, *Metapenaeus monoceros*, *M. brevicornis*, *Parapenaeopsis sculptilis* and *P. stylifera*; five species of Palamonidae *viz*. *Macrobrachium rosenbergii*, *M. villosimanus*, *M. lamarrei*, *M. mirabilis* and *Palaemon styliferus*; *Acetes* spp. of Sergestidae; one species of Alpheidae, *Alpheaus euphrosyne*; megalopa of two crab species *Scylla serrata* and *Neptunus pelagicus* representing Portunidae and Ocypodidae were recorded. The study revealed the predominance of *M. monoceros*, *M. brevicornis*, *M. villosimanus*, *Acetes* spp. and crab megalopa totaling 79.3–96.83% in five rivers of Sundarbans. These species were observed all along during the study period except Acetes. Frequency of monthly abundance of different species varied from river to river and also among the years. The less frequently occurring species were *P. indicus*, *P. stylifera*, *P. styliferus* and *A. euphrosyne* which were not observed in all the rivers. The commercial shrimps *P. monodon*, *P. indicus*, *M. monoceros* and *M. rosenbergii* comprised of 3.43–46.26% in 1998-99 and 4.32–26.21% in 1999-2000. No specific salinity zone preference was observed in the abundance of shellfishes in the rivers of Sundarbans. Contribution by most abundant seven species was high in Koyra river, located at freshwater zone, while commercial shrimp species were highly abundant in Kholpatua river of semi-saline zone. Abundance of *P. monodon* was high in Madar located in saline zone and crab megalopa of commercial species (*S. serrata*) was highly abundant in Koyra river.

The size of the postlarvae and juveniles abundant in the rivers of Sundarbans varied with species. The mean body length of penaeid shrimp was between 10-38 mm. Larger size *M. monoceros* were frequently recruited in all rivers and the size of *P. monodon* was mostly uniform. Caridean size was more variable, mean body length ranged from 10 mm to 26 mm. However, the size of shrimp restricted to <40 mm, as numbers of individuals of >50 mm were recorded during sampling. *M. monoceros* with >35 mm body length were more abundant in winter. *Acetes* body length varied from 14 mm to 28 with some up to 36 mm. The mean carapace length of crab megalopa was between 1-4 mm and a few megalopa with 10 mm carapace length were observed during winter. A few specimens of 1st crab stage were also noticed during sampling. The recruitment size of commercial shrimp species in different seasons are presented in figure 3.

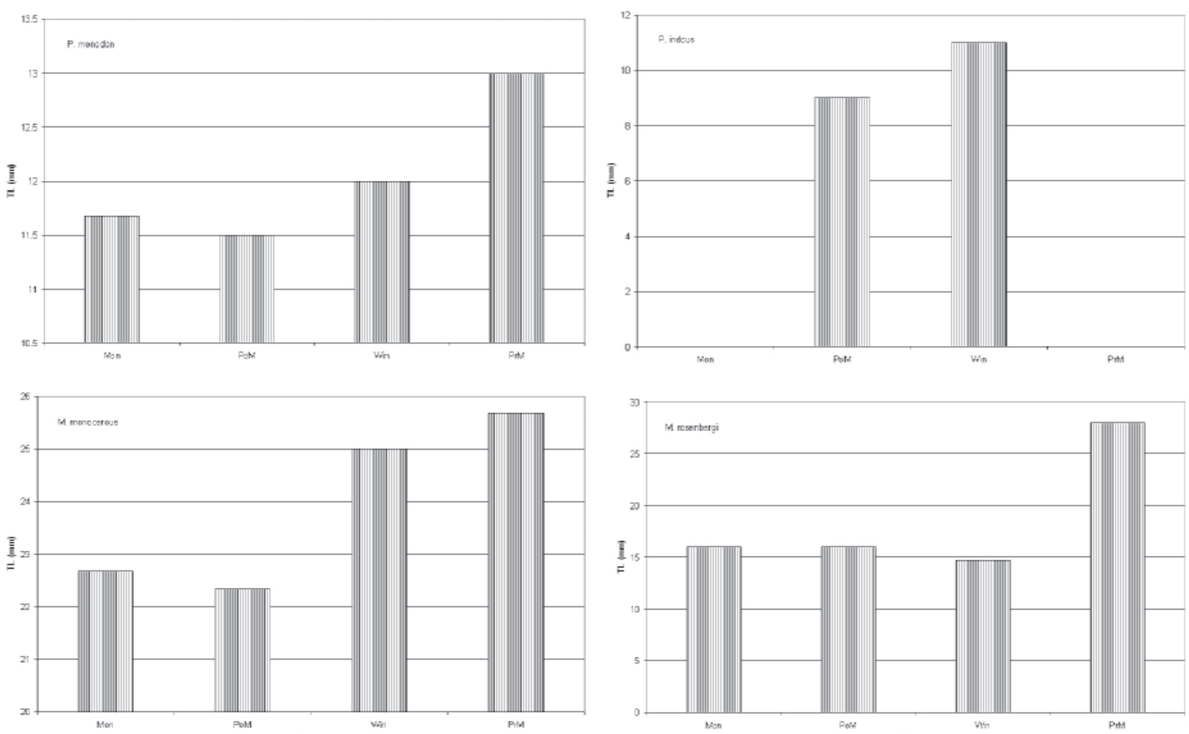


Fig. 3. Seasonal mean total length (TL) of commercially important shrimp species in rivers of Sundarbans. Mon, monsoon; PoM, post monsoon; Win, winter PrM, premonsoon.

The most abundant seven species of shellfishes in rivers of Sundarbans showed variability during individual years rather than among the years (Table 2). *M. monoceros* showed higher variability during 1998-99 than among years in Koyra, Kholpatua and Madar river (C.V.w>C.V.a). *M. brevicornis* showed such trend in Kholpatua river only. *M. villosimanus* showed higher variability in Passur, Koyra, Kholpatua in 1st year and Sibsa and Madar rivers in 2nd year. *Acetes* spp. and crab megalopa showed variability in Passur and Koyra river in 1st year and in Sibsa, Kholpatua and Madar rivers in 2nd year. No inter-annual variation for most abundant shellfishes was observed.

Table 2. 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 the most abundant species in rivers of Sundarbans

Species	1998-99			1999-2000			Among years	
Passur river	Month	D_w	$C.V._w$	Month	D_w	$C.V._w$	D_a	$C.V._a$
M. monoceros	July	3.64	68.68	June	3.4	81.69	-	74.38
M. brevicornis	"	5.0	143.8	"	3.17	129.65	-	138.14
P. sculptilis	October	7.2	113.47	August	29.0	81.76	-	88.07
M. villosimanus	July	72.36	162.65	June	20.92	109.32	-	150.69
M. mirabilis	October	7.92	139.65	July	22.1	132.26	-	134.24
Acetes spp.	September	91.08	198.5	"	27.71	94.41	-	174.21
Crab megalopa	October	52.5	141.79	"	147.1	106.31	-	115.64
Sibsa river								
M. monoceros	December	7.57	82.43	July	14.25	90.11	-	87.44
M. brevicornis	November	8.71	133.87	"	21.9	150.59	-	145.79
P. sculptilis	December	21.5	30.51	August	2.0	0	-	55.83
M. villosimanus	November	83.45	154.63	"	8.17	172.95	-	156.28
M. mirabilis	December	27.5	150	July	1.0	0	-	289.47
Acetes spp.	November	14.25	93.82	December	7.0	106.71	-	98.02
Crab megalopa	"	19.34	74.15	July	24.75	116.69	-	98
Koyra river								
M. monoceros	June	23.06	158.24	July	17.92	100.17	-	132.85
M. brevicornis	July	6.91	140.52	"	14.9	142.01	-	141.52
P. sculptilis	December	9.67	78.48	October	1.5	38.67	-	74.29
M. villosimanus	September	52.23	188.9	July	18.8	158.56	-	180.86
M. mirabilis	October	2.0	0	-	-	0	-	0
Acetes spp.	June	26.14	157.38	July	13.12	107.85	-	140.86
Crab megalopa	"	70.38	302.16	"	38.67	191.18	-	262.79
Kholpatua river								
M. monoceros	June	51.67	154	June	20.25	72.54	-	131.06
M. brevicornis	"	18.44	198	"	10.25	121.07	-	170.45
P. sculptilis	February	15.0	0	January	6.2	132.29	-	213.04
M. villosimanus	September	37.67	162.94	June	11.27	124.67	-	154.15
M. mirabilis	June	10.5	101.05	March	1.0	0	-	184.52
Acetes spp.	"	6.23	92.78	"	13.67	135.33	-	122.01
Crab megalopa	"	4.92	126.83	June	29.58	267.17	-	247.19
Madar river								
M. monoceros	June	10.88	121.23	July	3.5	64.86	-	107.51
M. brevicarnis	"	17.0	183.29	June	5.0	107	-	166
P. sculptilis	February	8.0	109	August	29.8	184.46	-	168.52
M. villosimanus	August	13.17	104.33	"	8.0	170	-	129.08
M. mirabilis	June	8.5	118.71	June	11.25	65.87	-	88.56
Acetes spp.	"	20.23	106.13	"	107.5	245.77	-	223.64
Crab megalopa	"	4.71	149.25	"	105.17	293.29	-	287.11

Seasonality and variation of the most abundant species

Maximum shrimp individuals were recorded at 126/haul during monsoon in Passur, 396/haul during postmonsoon in Kholpatua, 780/haul during winter in Madar and 687/haul during premonsoon in Passur river. Highest number of individuals 1079/haul was recorded for crab megalopa during monsoon in Madar, followed by 866/haul during postmonsoon in Koyra, 521/haul during winter in Passur and 263/haul during premonsoon in Koyra river. Seasonal abundance of shrimp was higher in 1st year, whereas crab megalopa was higher in 2nd year. Shrimp were less abundant in monsoon in the rivers of Sundarbans.

Among most abundant shellfishes, *P. stylifera*, *M. mirabilis* are site specific and were absent in monsoon towards winter in some rivers. *M. monoceros*, *M. villosimanus* and *M. mirabilis* were more abundant in postmonsoon and winter, whereas *M. brevicornis* and crab megalopa were more abundant in monsoon and postmonsoon period. Seasonal distribution of average numbers of *M. villosimanus*, *Acetes* spp. and crab megalopa was high in the rivers of Sundarbans. Seasonal distribution of crab megalopa was uniform in the rivers of Sundarbans.

There was no significant effect of season or lunar cycle on the abundance or distribution of most abundant shellfishes in five rivers of Sundarbans. *M. monoceros* and *M. villosimanus* were more abundant in postmonsoon and winter, however the occurrence is not statistically significant.

Similarities of species abundance

The dendrogram (Fig. 4) showed three major clusters of abundant shellfish species in rivers of Sundarbans separated into two years. At a dissimilarity level of <1% *M. monoceros*, *M. brevicornis*, *M. villosimanus*, *Acetes* spp. and crab megalopa assemblaged in 1st year are comparable to *M. monoceros* assemblaged in second year. Maximum assemblage occurred in *M. monoceros*, *M. villosimanus* and crab megalopa during second year and minimum assemblage observed in *P. sculptilis* and *M. mirabilis* in both years.

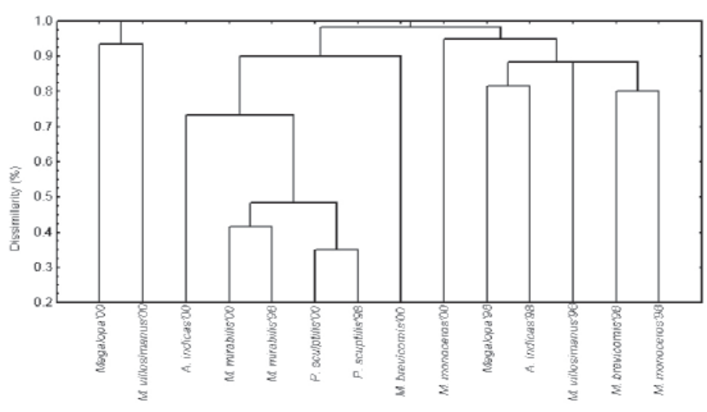


Fig. 4. Dendogram showing the assemblages of most abundant shellfishes

Abundance of P. monodon PL and loss of biodiversity

To assess the loss of biodiversity in Sundarbans water, an estimate of other species during *P. monodon* PL collection was done (Table 3). When compared with previous two years (1992-93 and 1995-96) study (Hoq et al. 2001), abundance of *P. monodon* PL was significantly ($P<0.05$) reduced during 1995 and 1998-2000 compared to 1992 in Passur and Kholpatua rivers; during 1995 and 1998 in Koyra. In Sibsa, variations in *P. monodon* abundance was not statistically significant, whereas in Madar river abundance reduced in 1995 than increased in 1998 and again reduced in 1999. Availability of other shrimp spp. and finfishes were significantly ($p<0.05$) increased in present study compared to previous years. Composition of macro-zooplankton which includes *Acetes* spp., crab megalopa, mysids etc. reduces significantly in the present study. It was estimated that to catch a single *P. monodon* PL, 12-419 other shrimp postlarvae, 5-105 fish larvae and 26-488 other macro-zooplanktons are thrown to the dry river bank, resulting a high rate of "wastage". Shrimp species other than *P. monodon* included species identified in the present study. On the other hand finfishes represent many commercial species like *Mugil* spp., *Liza* spp., *Lates calcarifer*, *Tenulosa ilisha*, etc.

Table 3. Number of species wasted for each *P. monodon* PL collected during 1992 to 2000

Rivers	Species	1992-93	1995-96	1998-99	1999-2000
Passur	Other shrimp	12	96	419	180
	Finfish	5	20	97	105
	Macro-zooplankton	26	84	71	99
Sibsa	Other shrimp	48	55	285	199
	Finfish	16	11	80	28
	Macro-zooplankton	390	488	34	65
Koyra	Other shrimp	16	49	342	73
	Finfish	11	18	72	7
	Macro-zooplankton	61	226	141	29
Kholpatua	Other shrimp	31	60	104	68
	Finfish	7	17	41	16
	Macro-zooplankton	113	163	4	24
Madar	Other shrimp	25	33	48	130
	Finfish	5	12	11	8
	Macro-zooplankton	61	242	3	64

Species abundance in relation to water parameters

Water temperature and salinity were the two environmental parameters to make a significant contribution to the explained variation in ordination among density of shellfishes in Sundarbans rivers. The correlation coefficients between temperature and salinity and the abundance of seven species were plotted in figure 5. Two out of seven species were found in the area with high salinity and high temperature, two species in low salinity and high temperature, one species in high salinity and low temperature and rest two species in low salinity and low temperature areas during 1998-99. In 1999-2000, some species changed their position and the corresponding numbers were 1, 1, 1 and 4 respectively.

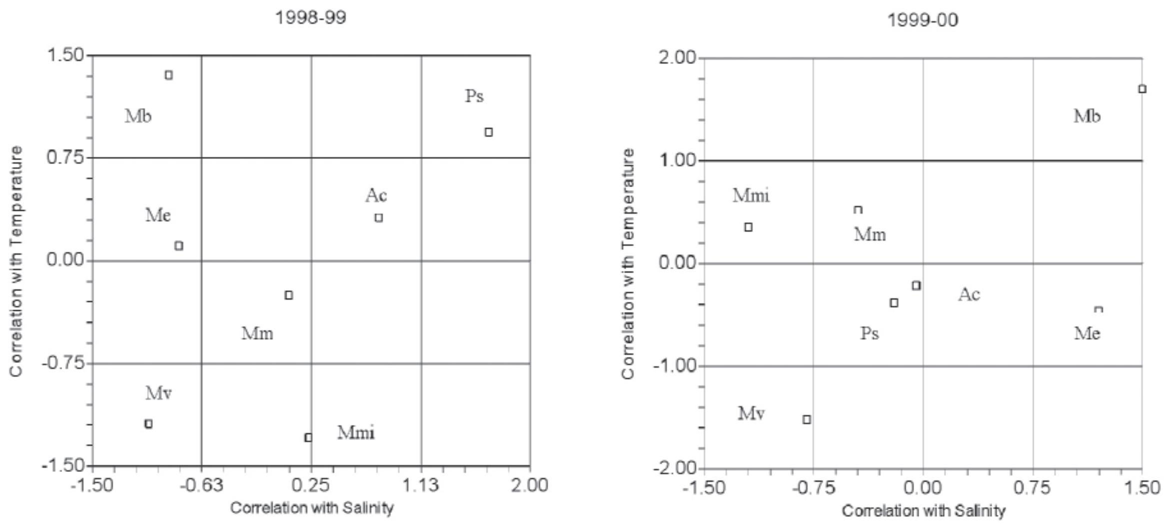


Fig. 5. Ordination of 7 dominant shrimp species in the rivers of Sundarbans on correlation coefficients (r) for temperature (Y-axis) and salinity (X-axis). (Mm: M*etapenaeus monoceros*, Mb: *M. brevicornis*, Ps: *Parapenaeopsis sculptilis*, Mv: *M. villosimanus*, Mmi: *M. mirabilis*, Ac: *Acetes* spp.)

Discussion

The Sundarbans is an unusual mangrove ecosystem. The forest is flushed year-round with upland river water, and salinity remains relatively low. A dominant plant species, *Heritiera fomes*, a species practically unknown in mangrove forest elsewhere in the world, does not posses an adaptive tolerance to high salinity. Diversity indices for the shrimp species recorded in the present study were low because of the high dominance of a few non-commercial shrimp species (*M. villosimanus*, *Acetes* spp. etc.), which are widely distributed in shallow waters. Studies revealed that although many species are represented in mangrove ecosystems, a few are abundant (Robertson and Duke 1987, Chong et al. 1990). An increase in the number of species, and hence in diversity during premonsoon (Mar.-May) was clear from this study. Species composition of shellfishes indicates that the postlarval and juvenile shrimp assemblage in the Sundarbans mangrove constituted of a few species in large numbers. Juvenile shrimps occurred abundantly throughout the year with varying size groups in different seasons. Megalopa of crab was more abundant during winter in freshwater zone, whilst their abundance was peak during monsoon in semi-saline to saline zones. Monthly variation in density of *P. monodon* PL abundance was broadly similar among rivers. Major peak occurred from November through February, 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, PL migrate to the mangrove waters for their further development (Staples and Vance 1985). Metapenaeus, especially *M. monoceros* and *M. brevicornis* were predominant throughout the year in the Sundarbans water. These species often occurred in creeks with dominant mangrove plants (Rajendran 1997), and are detritus feeder (Chandrasekaran 1986). Catchability of penaeids postlarvae in the Chakaria estuary, Bangladesh was higher at night in comparison to that of the day, and they immigrate in higher density through bottom waters during the day which is reversed at night (Mahmood 1990). These pattern was also supported by Vance and Staples (1992) in Embley estuary, Australia. Night sampling was not included in the present study.

Mahmood and Zafar (1990) reported that immigration of penaeid PL takes place throughout the year in Satkhira estuary (Sundarbans) with peak abundance during monsoon and minimum in premonsoon. The penaeid PL was dominated by *M. monoceros* (51.05%), *P. monodon* (14.75%) and *M. brevicornis* (3.02%). In the present study, major peak of penaeid PL was in winter and lean period was in monsoon. 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% penaeid and 35.9% caridean with major peak during postmonsoon and lean during winter in the Satkhira estuary, while findings of the present study was 28.44% penaeid and 45.86% caridean, the rest was crab megalopa. Caridean PL were also mostly abundant in winter and lean during premonsoon i.e. summer. Although juveniles of the various shrimp species are seasonal in occurrence, penaeid PLs as a whole were abundant throughout the year. Thus there is apparently little spatial or temporal correlation between recruitment of other species of shrimps. Two peak abundance for *S. serrata* megalopa were recorded in the present study. Winter (Dec.-Feb.) peak was observed in freshwater zone, whereas monsoon (Jun.-Aug.) was in saline zone (Kholpatua and Madar rivers) and crab megalopa was less abundant in postmonsoon.

During two years of study at least 15 species of shellfishes were recorded, which is comparable with records of Basu et al. (1998) at Hooghly estuary, Indian Sundarbans. They recorded 10-21 crustacean species with major abundance of *Acetes* spp. (12.88%), followed by *S. serrata* (9.74%) and *P. monodon* (6.01%) and maximum species diversity during premonsoon. Similar to the present study, eight species of penaeid shrimp were recorded with *M. monoceros* and *M. brecvicornis* as dominant species in all seasons in Pichavaram mangrove, India (Rajendran and

Kathiresan 1999). Penaeid shrimps were reported to be abundant during premonsoon in mangrove water of Goa, India with predominantly *M. dobsoni*, *M. monoceros* and *P. merguiensis*. Year round recruitment was taking place only in *M. monoceros* (Achuthankutty and Nair 1982). Seasonal abundance of *P. monodon* and *P. indicus* was reduced in Hooghly-Matlahc estuary, India in post-Farakka barrage period compare to pre-Farakka barrage period (De and Sinha 1997). Although, it is generally believed that abundance of *P. monodon* PL in Sundarbans coast is being reduced, the causes of such reduction could not be understood. This decline of *P. monodon* PL from 1992 or even from 1989 (Mahmood and Zafar 1990) to 2000 is a potential threat to their future. From September 2000 Government of Bangladesh has banned collection of *P. monodon* PL from wild, but the regulation is not possible to implement in long coastal belt of Bangladesh. However, as reserve forest, this regulation can be implemented in Sundarbans.

In the present study, mysid were excluded from the calculation although they were abundant numerously in Passur, Kholpatua and Madar rivers during sampling. *Acetes* known as sergestid shrimp is assumed to play a significant role in the food web and dynamics of coastal water, sea grass beds and mangrove swamps which are commonly distributed in estuarine and coastal waters of Bangladesh (Zafar 1992). It is essential that the shrimp postlarvae reach the small creeks and brackish waters of the estuaries to find shelter and food. The recruitment of shrimp in the deep sea is directly dependent on the survival of these juveniles in the mangrove nursery grounds. If these are reclaimed and/or juveniles are captured, this will negatively reflect on the adult population. This scenario will also apply to finfish larvae, indiscriminately exploited with the targeted *P. monodon* PL, with disastrous effects on artisanal and commercial fisheries in the near future. The indiscriminate wastage of ichthyoplankton to meet the demand of shrimp culture farms in the coastal zone of the Indian continent may not only endanger the ecology of coastal areas (Trivedi et al. 1994), but will also lead to a fall in coastal catches (Mitra et al. 1998).

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). No distinct recruitment pattern of shrimp postlarvae was identified in the present study, although peak abundance of *M. monoceros*, *M. brecvicornis* and *M. villosimanus* were recorded during September to February (postmonsoon and winter). The pattern of twice yearly juvenile recruitment to the mangrove sites coincides 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. The spring tides coincide with full and new moons rendering it difficult to separate the effects of moon phases from tidal heights. Numerical superiority of new moon catches over full moon collections on seed catchability, clearly indicate that moon phase affect the abundance of penaeid shrimp seed (Gunaga et al. 1991). In this study, no significant lunar effect on shrimp abundance was observed.

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