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Temporal distribution and abundance of shrimp postlarvae and juveniles in the mangroves of Muthupet, Tamilnadu, India

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Abstract

The temporal distribution patterns of the predominantly occurring postlarvae and juvenile shrimps in the mangrove and associated habitats of Muthupet, India were investigated for two years from February 1984 to January 1986. Among the eight commercially important species recorded, *Penaeus indicus* H. Milne Edwards, *P. merguiensis* De Man, *P. monodon* Fabricus and *Metapenaeus dobsoni* (Miers) were predominant. The postlarval recruitment size varied with species: *P. indicus* and *P. merguiensis* recruited at the size of 9–11 mm total length (TL), *P. monodon* at 12–14 mm TL and *M. dobsoni* at 4–6 mm TL. The species *P. indicus*, *P. merguiensis* and *M. dobsoni* were observed continuously throughout the study period with maximum abundance occurring from July to September in 1984–85 and from August through October in 1985–86. *P. monodon* occurred seasonally from November to January in both years. Postlarvae and juvenile catches were low during low salinity and high salinity periods and a higher density was observed in the months of moderate water salinity. Large numbers of *P. indicus*, *P. merguiensis* and *M. dobsoni* clearly showed the preference to the detritus rich muddy substrate, whereas *P. monodon* did not show any preference and was equally abundant over different substrate types.

Introduction

India, a major shrimp supplier in the Indo-Pacific region, generates considerable revenue through export of shrimp to Japan, USA, Europe and other countries. The annual production of penaeid shrimps in India was estimated to be 117 000 tonnes in the year 1985. The value of Indian shrimp exported to United States alone was estimated to be US $ 56.9 million (U.S. Department of Commerce, 1988).

Most of the penaeid shrimp species in India have a similar life history pattern. Adults spawn in deep waters, and post larvae and juveniles use inshore estuarine and coastal waters as nursery habitats for their early development. The use of mangroves as nursery grounds for penaeid prawns in India (Suseelan & Kathirvel, 1980; Chakroborthy *et al.*, 1982; Sambandam *et al.*, 1982; Babu & Babu, 1986; Silas, 1986; Subramanian, 1987; Rao, 1990) and in other parts of the world (de Freitas, 1986; Stoner & Zimmerman, 1988; Vance *et al.*, 1990) has been reasonably well studied. A positive statistical correlation between commercial yields of shrimp and extent of mangrove forests has been well established. (MacNae, 1974; Martosubroto & Naamin, 1977; Turner, 1977; Staples *et al.*, 1985; Silas, 1986; Chong *et al.*, 1990). Destruction of mangroves was considered as one of the major factors contributing to the decline in prawn catches in El Salvador (Daugherty, 1975). High abundance of juveniles in tropical estuaries and success of shrimp fishery in the tropical inshore areas has been attributed to high concentrations of mangrove-derived detritus in the nearshore ecosystems (Stoner & Zimmerman, 1988; Longhurst & Pauly, 1987).

In India, 256 000 hectares (Blasco, 1976) of mangrove swamps present along the east and west coasts play a vital role as nursery grounds for penaeid shrimps. Surveys of shrimp fry resources in mangrove estuaries on the east coast of India indicated catch rates of up to 4600 and 6200 fry of *P. monodon* and *P. indi-*

cus respectively per man hour of operation (ICAR, 1978). Postlarvae and juveniles have been traditionally exploited by artisanal fisheries and as wild seeds for aquaculture (Macintosh, 1982; Silas, 1986). Fishing at this stage reduces the recruitment of the next fishery, ultimately affecting the spawning potential to the extent that postlarval recruitment could be diminished (Garcia, 1988). Despite many studies of prawn seed resources on estuarine mangroves along Indian coastline (Macintosh, 1982), very little information is available on the mangrove lagoon of Muthupet at the Palk Straight along the east coast.

The present paper is a study describing the species composition and quantitative monthly variation of postlarval and early juvenile shrimps in mangrove estuarine areas of Muthupet, Tamil Nadu, India.

Description of the study sites

The mangrove swamp of Muthupet (lat. 10 ° 25′N; long. 79 ° 30′E) is located at the southern end of the Cauvery delta, 73 km from Thanjavur in the State of Tamil Nadu, India (Fig. 1). The drainage tributaries of the river Cauvery enter the Palk strait through a lagoon in this region. An extensive mangrove swamp occurs in the deltaic interface area between the drainage tributaries, lagoon and sea. The swamp is composed of many islands and islets that are traversed by numerous interconnecting channels, creeks, inlets and rivulets. In the river Koreiyar, which is the main source of freshwater to Muthupet mangrove lagoon, a weir was installed at about 11 km upstream to control and augment water for irrigation in the upland fields near the rivers.

Materials and Methods

The two-year study from February 1984 to January 1986 was conducted at three sampling stations (Fig. 1) established along the river Koreiyar and lagoon, surrounded by pure stands of *Avicennia marina* (Forsk.) Vierh. The water depth at the sampling sites varied from 0.5 to 1.5 m. Station I was in a bayou connected to the river Koreiyar and characterized by muddy substratum covered by a thick stratum of detrital peat material. Pneumatophores of mangroves were present and algal vegetation was not observed. Station II was in the river Koreiyar, 600 m downstream from Station I. The substratum was muddy and stratum containing very thin layer of detritus. Station III was located in the lagoon where the sandy substratum was densely covered by algal vegetation dominated by *Gracilaria* and *Enteromorpha* spp.

A rectangular pocket seine net having a mesh size of 2 mm, 2 m in length and 1 m deep was used for the postlarval and juvenile collections. For each sampling, the net was dragged twice by two people, starting from shallow waters and continuing to the adjacent shore, covering a total area of 10 m^2. The collections were carried out for a period of two years on a fortnightly basis. The collected samples were preserved in 5% formalin for further analysis in the laboratory. The postlarvae and early juveniles less than 20 mm total length (TL) were sorted out and identified to species by their color, location and distribution of the chromatophore on the various parts of the body, length of the rostrum, presence or absence of rostral spines, spinnules on dorsal carina of the 6th abdominal segment and spine on the carapace. The descriptive guidelines outlined by Muthu (1978) and Motoh & Buri (1980) were followed.

Surface water temperature and salinity were also measured during sampling with a stem thermometer and temperature compensated refractometer. Rainfall data recorded at Meteorological Department, Adirampattinam were used. Analysis of Variance (ANOVA) was carried out by SAS General Linear Models (GLM) procedures to examine the effects of year, month, station and interactions on temperature, salinity and numerical abundance of shrimps (SAS, 1985). Following ANOVA results, Tukeys' Studentized Range Test was also conducted to compare the specific variability of shrimp density among the stations (SAS, 1985).

Results

Annual precipitation was 1412 mm in 1984–85 and 1285 mm in 1985–86 (Fig. 2). The major percentage of rainfall in this area was during the monsoon months between October and December. However, unprecedented rainfall was recorded in February (284 mm), March (160 mm) and July (230 mm) during the year 1984–85.

The seasonal variation in mean surface water temperature (Fig. 2) ranged from 24.2 to 32.6 °C in 1984-85, a difference of 8.2 °C, whereas in 1985–86, it ranged between 28.6 and 31.4 °C, a difference of only 2.8 °C. In both years, annual lows occurred in February and highs in May. ANOVA test (Table 1) showed highly significant ($P<0.01$) interannual and month-

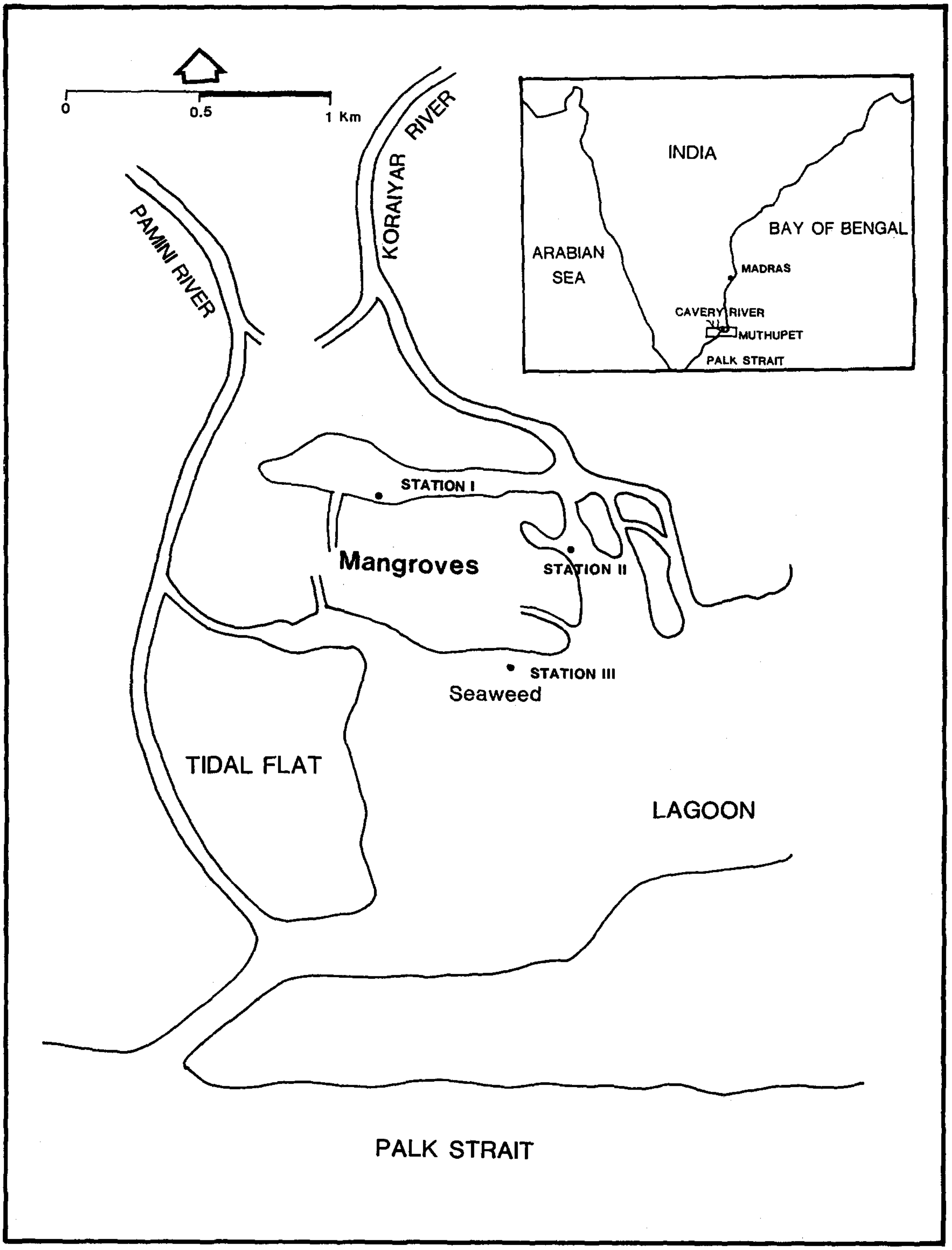

Fig. 1. Location of the shrimp collection sites in the mangrove areas at Muthupet, Tamil Nadu, India.

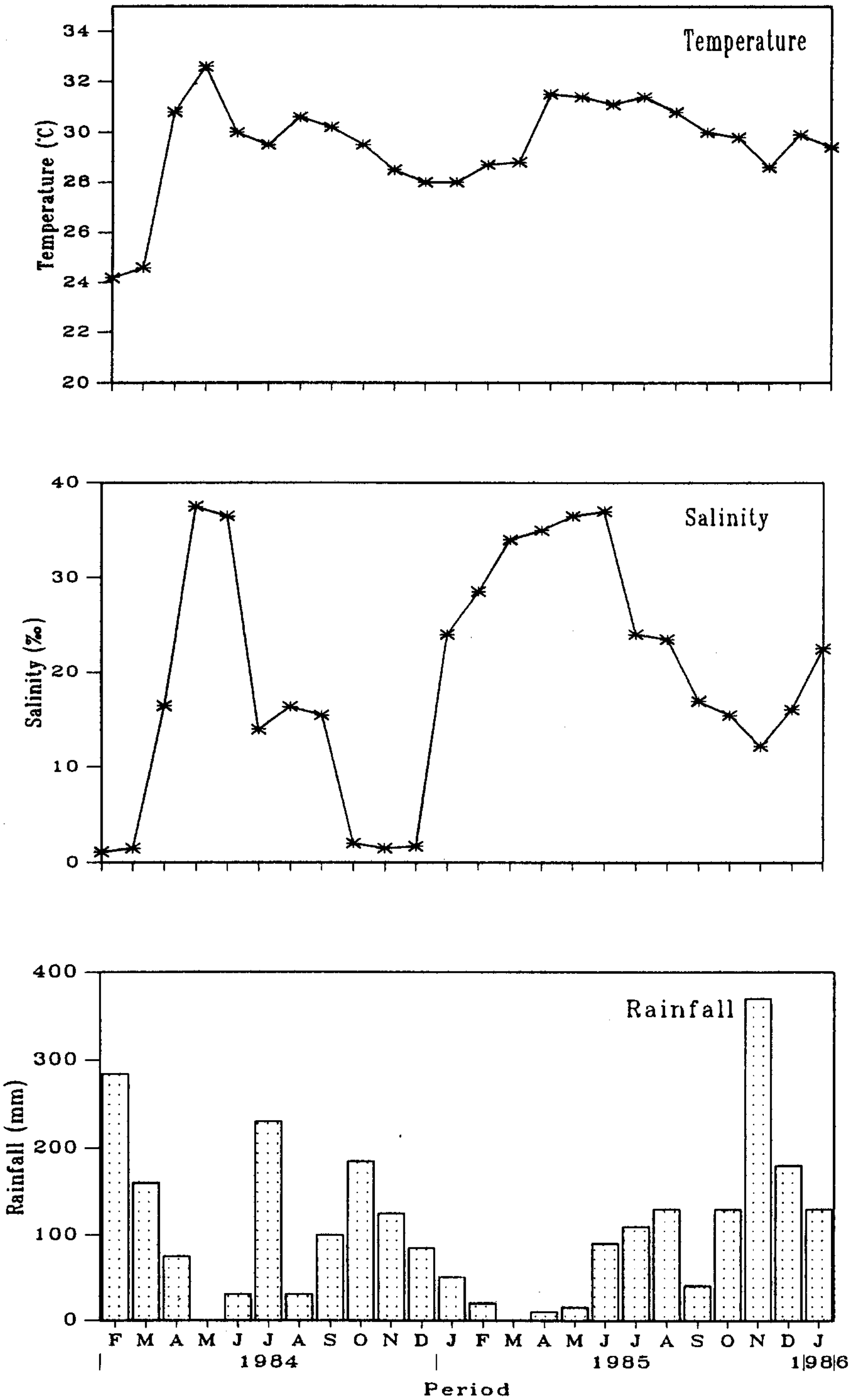

Fig. 2. Monthly water temperatures (°C), salinities (‰) and rainfall (mm) recorded at Muthupet, India during the period from February 1984 to January 1986.

Table 1. Analysis of Variance (ANOVA) of the effects of year, month, station and interactions on temperature and salinity in the mangroves of Muthupet, India from February 1984 through January 1986. (d.f. = degrees of freedom, SS = sums of squares, MS = SSld.f., F = MSamong/MS within

Source	d.f	SS	F
Temperature			
Year	1	29.26	4221.3**
Month	11	189.74	2488.37**
Station	2	0.01	0.98
Year ⊗ Month	11	47.97	629.16**
Year ⊗ Station	2	0.01	0.54
Month ⊗ Station	22	0.27	1.79
Error	22	0.15	
Salinity			
Year	1	2090.89	31244.98**
Month	11	6706.33	9110.49**
Station	2	0.08	0.62
Year ⊗ Month	11	1771.44	2406.49**
Year ⊗ Station	2	0.19	1.45
Month ⊗ Station	22	1.58	1.08
Error	22	1.47	

** = $P < 0.01$

ly variations in temperature. Station differences were never greater than 0.4 °C and ANOVA test yielded no significant variation.

Salinity ranged from 1.1 to 37.6‰ in 1984–85 and 12.2 to 37.6‰ in 1985–86. In general, annual low salinity occurred in monsoon months from October through December. Following the monsoon season, salinity steadily increased and reached its maximum in May. Then, there was a gradual decline in salinity from June to a minimum in the monsoon months. The decrease in salinity from June was due to river discharge and land drainage following the opening of Mettur dam for irrigation in the Cavery basin during southwest monsoon rains in the nearby western state of Karnataka. However, low salinity during February, March and July 1984 was apparently due to unprecedented heavy rains and floods. ANOVA test indicated highly significant ($P<0.01$) effect of year and month on salinity (Table 1). The variation in salinity among the stations was not significant.

The postlarvae and juveniles of eight species of penaeid shrimps viz. *P. indicus*, *P. merguiensis*, *P. monodon*, *P. semisulcatus* De Haan, *M. dobsoni*, *M. monoceros* (Fabricus), *M. brevicornis* (H. Milne Edwards) and *M. affinis* (H. Milne Edwards) were recorded. The study revealed the predominance of *P. indicus* (39.31%), *M. dobsoni* (27.66%), *P. merguiensis* (17.82%) and *P. monodon* (19.62%), totalling 95.41%. The remaining 4.59% was comprised of *P. semisulcatus* (1.33%), *M. monoceros* (2.27%), *M. affinis* (0.40%) and *M. brevicornis* (0.59%). *P. indicus* and *M. dobsoni* dominated the samples and were recorded continuously in all months of the entire study period. The size of the postlarvae recruited in the mangroves varied with species. Most of the *P. indicus* and *P. merguiensis* recruited at 9–11 mm size, *P. monodon* at 12–14 mm size and *M. dobsoni* at 4–6 mm size. The species *P. indicus*, *P. merguiensis* and *M. dobsoni* were more abundant in Stations I and II than Station III. But *P. monodon* catches did not show any variation in distribution among the stations.

P. indicus

The postlarvae and juveniles of this species were collected throughout the study period (Fig. 3). During 1984–85, the mean monthly density was maximum (17.3 m^{-2}) during August and minimum during November (1.5 m^{-2}). In 1985–86, mean monthly density was higher in October (12.3 m^{-2}) and lower in February (3.9 m^{-2}). ANOVA results indicated that the density significantly varied with year, month, station and year-month interaction (Table 2). Large numbers were caught in Stations I (8.8 m^{-2}) and II (7.5 m^{-2}) than Station III (2.4 m^{-2}) (Fig. 4). Tukeys' test (Table 3) showed the collections made at Stations I and II were similar and significantly different from the catches from Station III.

P. merguiensis

This species showed maximum mean monthly density (6.7 m^{-2}) during August and minimum (0.2 m^{-2}) in December during 1984–85. In 1985–86, density maximum was noticed in October (7.1 m^{-2}), decreasing to minimum (3 m^{-2}) in April (Fig. 3). Differences in shrimp abundance were statistically significant ($P<0.05$) with year and highly significant ($P<0.01$) with month and station (Table 2). High concentrations at Stations I (4.2 m^{-2}) and II (3.3 m^{-2}) were evident (Fig. 4) and catches were significantly different from Station III (Table 3).

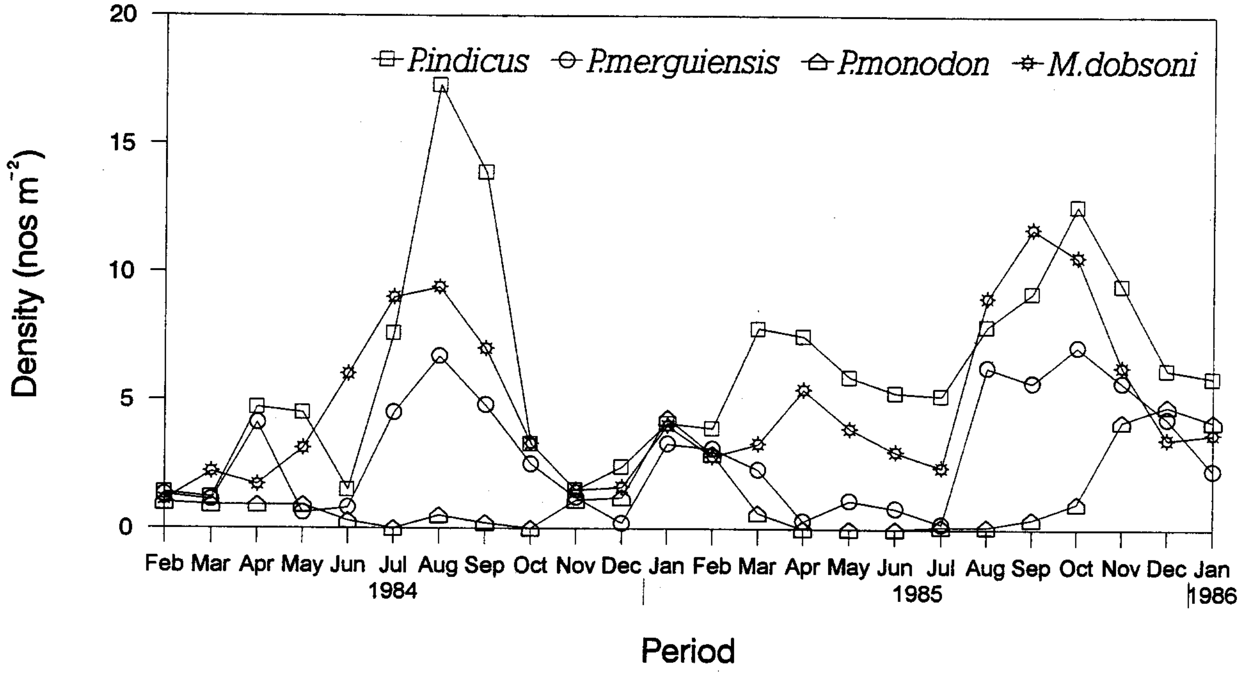

Fig. 3. Monthly mean density (nos m^{-2}) of penaeid shrimp postlarvae and early juveniles in mangroves at Muthupet, India from February 1984 through January 1986.

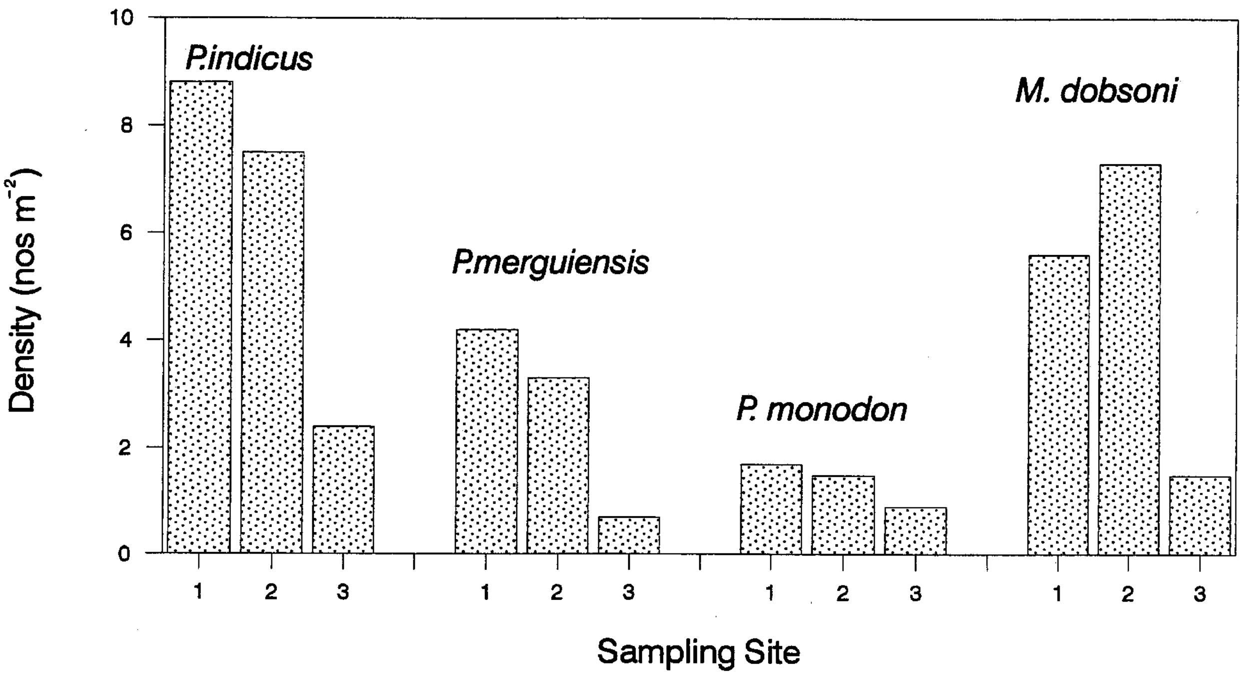

Fig. 4. Mean density (nos m^{-2}) of penaeid shrimp postlarvae and early juveniles collected at three sampling stations in mangroves of Muthupet, India from February 1984 through January 1986.

Table 2. Analysis of Variance (ANOVA) of the effects of year, month, station and interactions on numerical abundance of post larval and early juveniles in the mangroves of Muthupet, India from February 1984 through January 1986. (d.f. = degrees of freedom, SS = sums of squares, MS = SS/d.f., F = MSamong/MS within)

Source	d.f	SS	F
P. indicus			
Year	1	6981.68	8.83**
Month	11	61076.82	7.02**
Station	2	54827. 11	34.65**
Year ⊗ Month	11	46890.15	5.39**
Year ⊗ Station	2	1830.11	1.16
Month ⊗ Station	22	16897.56	0.97
Error	22	17404.56	
P. mergueinsis			
Year	1	1720.89	7.47*
Month	11	24202.11	9.55**
Station	2	15093.36	32.76**
Year ⊗ Month	11	10577.44	4.17**
Year ⊗ Station	2	1000.53	2.17
Month ⊗ Station	22	9445.97	1.86
Error	22	5068.14	
P. monodon			
Year	1	112.50	2.63
Month	11	19512.33	41.44**
Station	2	768.25	8.97**
Year ⊗ Month	11	2362.50	5.02**
Year ⊗ Station	2	102.25	1.19
Month ⊗ Station	22	2300.42	2.44
Error	22	941.75	
M. dobsoni			
Year	1	3120.50	7.52*
Month	11	40951.33	8.97**
Station	2	42672.00	51.42**
Year ⊗ Month	11	22772.17	4.99**
Year ⊗ Station	2	481.00	0.58
Month ⊗ Station	22	8261.67	0.90
Error	22	9129.33	

** = $P < 0.01$, * = $P < 0.05$

P. monodon

In both years, maximum mean monthly catches of 5.2 m^{-2} (1984–85) and 4.8 m^{-2} (1985–86) occurred in December (Fig. 3). Very few *P. monodon* were caught from April through July in both years. Highly significant (P<0.01) variation with month, station and year-month interaction was found in ANOVA test (Table 2).

Table 3. Comparison of shrimp postlarval and early juvenile mean densities (nos m^{-2}) at three sampling stations. Values in parenthesis are number of samples on which each mean is based. Means that are associated with the same letter (A or B) do not differ significantly as determined by Tukey's Studentized Range (HSD) test for mean comparisons (α = 0.05).

Species	Station I	Station II	Station III
P. indicus	8.8(24) A	7.5(24) A	2.4(24) B
P. mergueinsis	4.2(24) A	3.3(24) A	1.9(24) B
P. monodon	1.7(24) A	1.6(24) A	0.9(24) A
M. dobsoni	5.6(24) A	7.3(24) A	1.5(24) B

The mean density (Fig. 4) for Station I, II and III were 0.9 m^{-2}, 1.1 m^{-2} and 1.5 m^{-2}, respectively. This spatial distribution was not significantly varied as indicated by ANOVA (Table 2) and Tukeys' test (Table 3).

M. dobsoni

The mean monthly density of postlarvae and juveniles of *M. dobsoni* showed marked temporal and spatial variation. The monthly abundance (Fig. 3) was higher during August (9.4 m^{-2}) in 1984–85 and September (11.7 m^{-2}) in 1985–86. Minimum monthly density was observed in February in both years. ANOVA test (Table 2) indicated that the variation in shrimp abundance was significant (P<0.05) with year and highly significant (P<0.01) with month and station. Mean catch rates (Fig. 4) in Stations I (5.6 m^{-2}) and II (7.3 m^{-2}) were significantly higher and different from Station III (1.5 m^{-2}) (Table 3).

Discussion

In the present study the monthly variation in density of *P. indicus*, *P. merguiensis* and *M. dobsoni* was broadly similar. Major peak occurred from July through September in 1984–85 and from August to October in 1985–86. Minor peak appeared around March and April in both years. It is obvious that timing of the peak occurrence was more associated with moderate salinity (14–24‰) and that the poor recruitments were during the periods of both low and high salinity. Proper environmental conditions and some minimum standards in the health of the environment are required for the successful settlement of the penaeid seeds (Easo &

Mathew, 1989). Salinity differences have been found to influence postlarval recruitment of many penaeid shrimps (Garcia & Le Reste, 1981). Curtailment of *P. merguiensis* postlarval recruitment due to the onset of freshwater condition was reported in the Gulf of Carpentaria (Staples & Vance, 1987). A similar influence of salinity on the postlarve and juveniles was also observed in Cochin backwaters (Easo & Mathew, 1989) and Parangipettai coastal waters (Natarajan et a/, 1986). It has been reported that salinity more than temperature influenced the settlement of postlarvae in the Cochin backwaters (Kuttyamma, 1980). It is concluded that moderate rainfall extends the nursery area with preferred salinity regimes for successful settlement and growth (Barrett & Ralph, 1976; Garcia & Le Reste, 1981).

The density of *P. monodon* was found to be seasonal, occurring from December through February, which indicates seasonal spawning. The abundance of *P. monodon* was higher in 1985–86 than 1984–85. This may be due to existence of near freshwater conditions during the monsoon period of the year 1984–85 and supports the view that moderate salinity supports higher recruitment and settlement of postlarvae and juvenile penaeid shrimps.

It is clear from the data for the three sampling stations, the abundance of *P. indicus*, *P. merguiensis*, and *M. dobsoni* were more concentrated in Station I and II than in Station III. The substrate characteristics constitute the greatest physical variation in the sampling stations. Station I and II were characterised with detritus rich muddy substratum whereas in Station III, the substratum was sandy covered with dense seaweed. The detritus rich muddy substratum appears to be the preferred nursery habitat for postlarval and early juvenile shrimp of the above three species. The species *P. monodon* did not show any preference for types of substrate; its distribution being the same over the three stations.

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