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Full Length Research Paper

Influence of environmental parameters on shrimp post-larvae in the Sungai Pulai seagrass beds of Johor Strait, Peninsular Malaysia

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Monthly sampling for shrimp post-larvae was conducted between April 2007 and March 2008 from the seagrass beds of Sungai Pulai Estuary, Johor, Peninsular Malaysia. Samples were collected from sub-surface using a bongo net equipped with a flow meter. *In situ* environmental parameters such as water temperature, dissolved oxygen, pH, salinity, total dissolved solid and conductivity were recorded during each sampling time. Total catch was comprised of four major taxa namely: *Lucifer* (94.9%), *Acetes* (1.52%), *Penaeus* (0.13%) and *Mysis* (0.06%). Mean density of shrimp post larvae (PL) was calculated as 22,614.74 individuals/100 m^3. Peak abundance of *Penaeus* was found in June to July, while *Acetes* was found throughout the year with peak abundance in September. Higher abundance of *Lucifer* compared to the other genus was observed throughout the year with peaks in the monsoon months (May to July and October to December). The occurrence and abundance of *Mysis* was also restricted only in the monsoon months (November to January and May to July). There were significant correlation between the abundance of shrimp PL and *in situ* environmental parameters in the study area.

Key words: Shrimp post-larvae, seagrass beds, Peninsular Malaysia.

INTRODUCTION

The Sungai Pulai wetlands include Sungai Pulai Mangrove Forest Reserve (PMFR) and consists of mangroves, intertidal mudflats, seagrass beds and fresh water riverine forests. This wetlands form the district boundary between the mangrove forest located in Pontian and Johor Bahru districts. Seagrass beds in Sungai Pulai estuary is the most extensive, known to exist in the southern region of the Peninsular Malaysia (Jimmy, 2007). The seagrass beds support a variety of animals and some of them are considered as endangered species such as seahorse and dugong. The commercially important fishes, crabs, prawns and invertebrates like sea stars, sea cucumbers and anemone also thrive and form the high diverse community in the seagrass beds. Shrimp post larval (PL) abundance is an index to the fertility and provides information on the fishery potential of the area. The occurrence and abundance of larvae give an indication of the breeding season of the existing prawn species (Deshmukh and Kagwade, 1987). Seagrass beds and mangrove are the excellent feeding and nursery habitats of many fish and invertebrates during their juvenile stages (Nagelkerken et al., 2000). They inhabit in the habitat due to high abundance of food and low predation pressure (Huijibers et al., 2008). The seagrass beds are able to support a great abundance and several diversity of marine invertebrates including shrimps (Gillanders,

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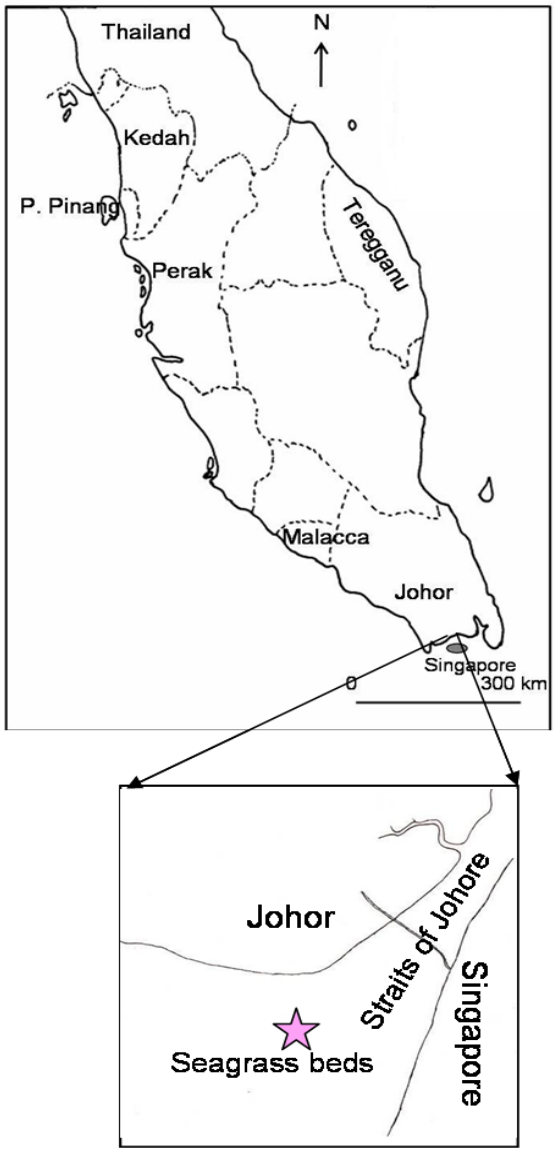

Figure 1. Geographical location of the sampling station in the seagrass beds of Sungai Pulai Estuary, Johor, Peninsular Malaysia.

2006), because of its richness in organic contents in the area. Sungai Pulai seagrass bed areas are protected from the full force of ocean waves and contains high organic detritus and rich in plankton for the feeding of these shrimps and their developing PL (Gulf of Marine Aquarium, 1998), enabling the shrimp PL to survive throughout their life cycle.

Based on the findings of Hoq et al. (2006), the occurrence of shrimp PL population in an area depends on water parameters and their tolerance to the extremes of the environmental variables, which is different among species. Any unexpected changes to the water parameters and other factors will affect the shrimp PL development, thus affecting the abundance of its population in an area (Mohan et al., 1995). No information is currently available on the occurrence and abundance of shrimp PL in the seagrass ecosystem of Malaysia except some works on the fish larvae (Ara et al., 2009; 2010a, b; Musa et al., 2010). Therefore, the present study was undertaken to determine the composition and temporal variation of the shrimp PL in the seagrass beds of Sungai Pulai estuary, Johor, Peninsular Malaysia. Additionally, investigation was taken to see the any possible correlation between the abundance of shrimp PL with the habitat environmental parameters.

MATERIALS AND METHODS

Study site and sampling

Seagrass beds of Sungai Pulai estuary (Figure 1) is located in the south coast of Johor, Peninsular Malaysia (1° 23' 15.86" N and 103° 32' 05.08" E). Monthly samples were collected from subsurface using a bongo net (500 µm mesh size of the body and cod end) equipped with a flow meter from April 2007 to March 2008. The net was towed at a depth of about 0.5 m from the surface for 30 min against the tidal flow. The samples were preserved in 5% formalin and then transported to the laboratory. *In situ* water quality parameters such as temperature, pH, salinity, total dissolved solid (TDS), dissolved oxygen (DO) and conductivity were reorded during every sampling time by using an environmental monitoring system (YSI 556 MPS, YSI Incorporated, USA).

Sample processing

In the laboratory, shrimp post-larvae (PL) were sorted out from the rest of the zooplankton and were preserved in 75% alcohol. Identification of each shrimp PL to the genus level was carried out based on appropriate literature (Mauchline, 1980; Chong, 1991; Daly and Holmquist, 1986; Mohamed et al., 1968; Omori, 1975, 1992). The raw catch data of PL at each tow were standardized to 100 m^3 based on the flow meter readings.

Data analysis

Pearson's correlation coefficient (r) was used to identify relationships between the abundance of shrimp PL and habitat parameters. Stepwise multiple regression analysis was used to examine the effect of shrimp PL abundance with water parameters. Multiple regression coefficients (R^2) were conducted using the following formula:

$$\text{Abundance PL} = \beta_0 + \beta_1\,(\text{DO}) + \beta_2\,(\text{temp.}) + \beta_3\,(\text{sal.}) + \beta_4\,(\text{pH}) + \beta_5\,(\text{TDS}) + \beta_6\,(\text{cond.})$$

Where β_0 is the intercept (constant) and β_1 to β_6 is the un-standardized coefficients of the water parameters. All analysis was performed using SPSS version 11.5.

RESULTS

Environmental parameters

The water temperature ranged from 26.92 to 31.68°C

Table 1. Temporal variation of water parameters in the seagrass beds of Sungai Pulai estuary, Johor, Peninsular Malaysia.

Months	Temp. (°C)	Sal. (ppt)	pH	DO (mg/L)	TDS (mg/L)	Cond. mS/cm
Apr	29.54	29.37	8.14	4.73	29.61	45.55
May	30.32	31.43	8.30	6.89	29.33	48.42
June	31.68	27.81	8.27	9.18	26.66	43.47
July	30.31	29.20	7.97	7.25	29.47	45.33
Aug	29.45	27.32	7.93	9.81	27.74	42.67
Sept	29.45	25.81	8.11	9.57	26.37	40.57
Oct	29.16	30.83	7.99	6.09	30.90	47.53
Nov	30.83	29.95	8.06	7.36	30.11	46.32
Dec	28.38	29.92	7.99	5.63	26.77	45.85
Jan	27.83	32.26	8.01	5.95	32.14	51.61
Feb	28.12	33.68	7.99	6.24	32.94	51.39
Mar	26.92	32.88	7.61	5.00	32.67	50.25
Mean	29.33	30.04	8.03	6.98	29.56	46.58
SE	0.39	0.68	0.05	0.50	0.67	0.99
Range	26.92 - 31.68	25.81 - 33.68	7.61 - 8.30	4.73 - 9.81	26.37 - 32.94	40.57 - 51.61

Tem. = temperature, Sal. = salinity, DO = dissolved oxygen, TDS = total dissolved solid, Cond. = conductivity.

Table 2. Composition and abundance (expressed as the mean no. of PL/100 m^3) of shrimp PL in the seagrass beds of Sungai Pulai estuary, Johor, Peninsular Malaysia.

Genus	Total PL	Mean PL (individuals/100 m^3)	Percentage (%)
Penaeus	39	31.74	0.13
Acetes	452	411.76	1.52
Lucifer	28171	21389.64	94.9
Mysis	19	15.27	0.06
Unidentified shrimps	1003	765.33	3.38
Total	29684	22613.74	100

(mean ± SE, 29.33 ± 0.39°C). The highest temperature (31.68°C) occurred during the month of June and the lowest was (26.92°C) in March (Table 1). Salinity of the seagrass beds ranged from 25.81 to 33.68 ppt (30.04 ± 0.68 ppt). The highest salinity (33.68 ppt) was recorded in February and the lowest (25. 81 ppt) in September. The pH levels fluctuated between 7.61 and 8.30 (8.03 ± 0.05). The highest pH (8.30) was found in May and the lowest (7.61) in March. Dissolved oxygen ranged from 4.73 to 9.81 mg/L (6.98 ± 0.50). Highest dissolved oxygen (9.81 mg/L) was observed in the month of August, while the lowest (4.73 mg/L) was in April. Total dissolved solid (TDS) ranged from 26.37 to 32.94 mg/L (29.56 ± 0.67). The highest TDS (32.94 mg/L) was recorded in February and the lowest (26.37 mg/L) in September. The conductivity ranged between 40.57 and 51.61 µS/cm (46.58 ± 0.99).

Highest value of conductivity (51.61 µS/cm) was recorded in January and the lowest (40.57 µS/cm) in September (Table 1). However, no significant ($p > 0.05$) variations were observed in water temperature, salinity, pH, dissolved oxygen, total dissolved solid and conductivity amongst the different months during the one year study period.

Composition of shrimp PL community

In total, 29,684 shrimp PL belonging to four taxa was recorded from the study area (Table 2). The dominant genus was *Lucifer* (94.9%), followed by *Acetes* (1.52%), *Penaeus* (0.13%) and *Mysis* (0.06%) in that order. The mean density of *Lucifer* PL was recorded as 21,390 individuals/100 m^3, while the mean density of *Mysis* PL was calculated as 15 individuals/100 m^3. The mean density of total shrimp PL was 22,614 individuals/100 m^3 (Table 2).

Temporal variation of shrimp PL

Genus Penaeus

Average density of *Penaeus* PL was found at 3 individuals/

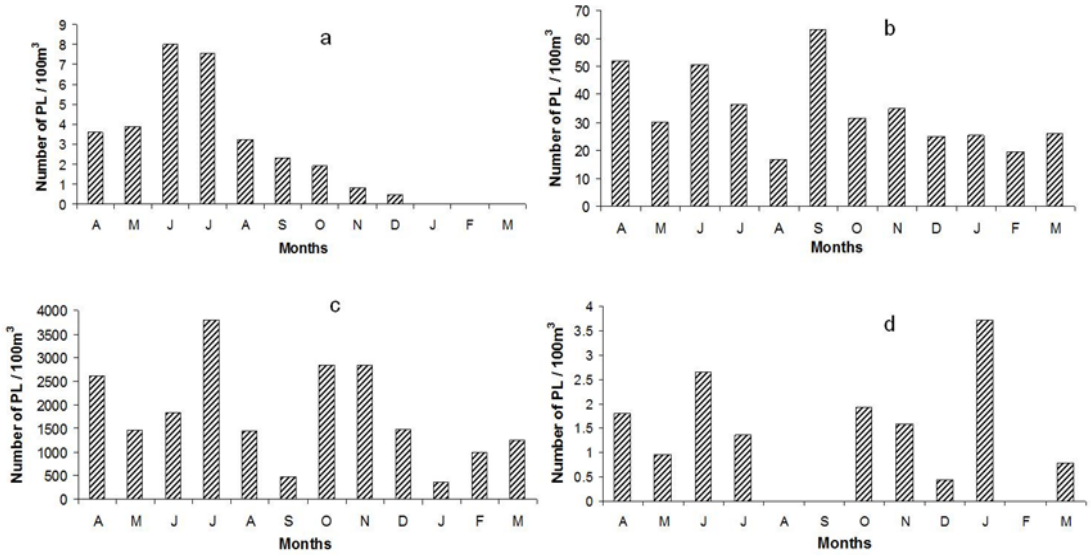

Figure 2. Monthly variations of different genus (a, *Penaeus;* b, *Acetes;* c, *Lucifer*; d, *Mysis*) in the seagrass beds of Sungai Pulai Estuary, Johor, Peninsular Malaysia.

Table 3. Correlation coefficients (r) between abundance of shrimp PL and environmental parameters in the seagrass beds of Sungai Pulai estuary, Johor, Peninsular Malaysia.

Genus	DO (mg/L)	Temp. (ºC)	Sal. (ppt)	pH	TDS (mg/L)	Cond. (mS/cm)
Penaeus	0.65*	0.77**	- 0.75*	0.52	- 0.60	- 0.72*
Acetes	0.33	0.70*	- 0.82**	0.50	- 0.54	- 0.78**
Lucifer	0.21	0.57	- 0.61	0.10	- 0.30	- 0.68*
Mysis	0.27	0.23	- 0.31	0.28	- 0.10	- 0.10

*Significant at 0.05 level, **Significant at 0.01 level.

100 m³. The highest density was recorded in June (8 individuals/100 m³; Figure 2a) and the lowest in December (0.4 individuals/100 m³). The abundance of *Penaeus* PL showed highly positive significant correlations with temperature ($r = 0.77$, $P < 0.01$) and dissolved oxygen ($r = 0.65$, $P < 0.05$). Lower degree of positive correlation was found with pH ($r = 0.52$, $P > 0.05$). Negative significant correlation was recorded with conductivity ($r = - 0.72$, $P < 0.05$) and salinity ($r = - 0.75$, $P < 0.01$; Table 3). The multiple regression co-efficient (R^2) between abundance of *Penaeus* PL and different environmental parameters was 0.70. This indicated that 70% abundance of *Penaeus* PL was influenced by the environmental parameters.

Genus Acetes

The average density of *Acetes* PL was calculated as 34 individuals/100 m³. The peak density of *Acetes* PL was recorded in September (63 individuals/100 m^3) and the lowest density was in August (17 individuals/100 m^3; Figure 2b). The correlation between *Acetes* PL and temperature showed positive significant correlation ($r = 0.70$, $p < 0.05$). Lower degree positive correlation was recorded with pH ($r = 0.50$, $p > 0.05$) and dissolved oxygen ($r = 0.33$, $p > 0.05$). High negative significant correlation was found between PL and conductivity ($r = - 0.78$, $p < 0.01$) and salinity ($r = - 0.82$, $p < 0.01$). However, there was a lower degree of negative correlation with total dissolved solid ($r = - 0.54$, $p > 0.05$; Table 3).

Genus Lucifer

The average number of *Lucifer* was recorded at 1,783 individuals/100 m^3. The highest mean abundance of *Lucifer* PL was recorded in the month of July with 3,792 individuals/100 m^3, while the lowest was in January (366 individuals/100 m^3; Figure 2c). The abundance of *Lucifer* PL showed positive non-significant correlation with temperature ($r = 0.57$), dissolved oxygen ($r = 0.21$) and pH ($r = 0.10$). However, there was a negative significant correlation with conductivity ($r = - 0.68$, $p < 0.05$). A lower negative correlation was recorded with salinity ($r = - 0.61$,

Table 4. Multiple regression equations between abundance of shrimp PL and environmental parameters in the seagrass beds of Sungai Pulai estuary, Johor, Peninsular Malaysia.

Multiple regression equation							
Penaeus	PL = 12.11 + 1.30	DO – 1.11	Temp – 0.52	Sal + 6.68	pH + 0.89	TDS – 1.04	Cond (R^2 = 0.70, p = 0.49)
Acetes	PL = 47.60 + 0.52	DO – 5.18	Temp – 5.46	Sal + 41.14	pH + 5.77	TDS – 4.25	Cond (R^2 = 0.86, p = 0.19)
Lucifer	PL = 8785.95 – 435.51	DO + 891.52	Temp + 77.75	Sal – 3200.97	pH + 232.49	TDS – 290.75	Cond (R^2 = 0.85, p = 0.22)
Mysis	PL = 5.74 + 0.16	DO – 0.29	Temp – 2.29	Sal + 1.08	pH + 0.25	TDS + 1.20	Cond (R^2 = 0.91, p = 0.10)

p > 0.05) and total dissolved solid (r = - 0.30, p> 0.05) (Table 3). Multiple regression co-efficient (R^2) between *Lucifer* PL and environmental parameters was 0.85 (Table 4), indicating 85% abundance of *Lucifer* PL was influenced by water parameters while the remaining 15% by other factors.

Genus Mysis

The average mean density of *Mysis* was found as 1.3 individuals/100 m^3. The highest mean abundance was recorded in January (3.7 individuals/100 m^3) and the lowest was in December (0.4 individuals/100 m^3; Figure 2d). Genus *Mysis* showed a positive correlation with pH (r = 0.28, p > 0.05), dissolved oxygen (r = 0.27, p > 0.05) and temperature (r = 0.23, p > 0.05). There was a highest degree of negative correlation with salinity (r = - 0.31, p > 0.05) and a lower degree of negative correlation with conductivity (r = - 0.10, p > 0.05; Table 3). The multiple regression co-efficient (R^2) between the abundance of *Mysis* PL and different habitat parameters were recorded as 0.91 (Table 4), which indicated that 91% abundance was influenced by environmental parameters and other factors were responsible for the remaining abundance.

DISCUSSION

Rivers, near shore habitats and straits have more variable water conditions, stronger currents and higher predation. Therefore, the shrimp larvae require the small creeks, seagrass beds and brackish waters of estuaries where they are protected and sufficient food resources are present for their development to PL and juvenile stages (Hoq et al., 2001; Zein-Eldin and Zoula, 1963). Heck et al. (2003) also reported that marine organisms that inhabit the seagrass beds are experiencing less predation rates compared to other habitats because of the structure and complexity provided by the seagrass bed area. In the present study, highest density of *Penaeus* PL was found in June and the lowest was in January to February and March. Mahmood and Zafar (1990) reported the highest abundance of penaeid PL in July and none was found in January, February and March in the estuarine waters of Satkhira, Bangladesh which is very similar with the present study. But the present results are dissimilar with Chong et al. (1996) in the Klang Straits, Malaysia because the penaeid PL seems to be present there throughout the year. Penaeid PL are euryhaline crustaceans (Chakraborti et al., 2002) which means that they can adapt to a wide range of salinity level, thus the high density of PL is due to the moderate level of water salinity recorded in the area.

Hoq et al. (2001) recorded the peak abundance of penaeid PL is linked to the moderate water salinity which is similar with the present study. This higher penaeid PL abundance may also be due to the monsoon season which comes in the month of May to September in the south-west region of Peninsular Malaysia where the salinity of water was low as been stated by Guru et al. (1993) and Mahmood and Zafar (1990). The statement is strengthened by the facts stated by Zein-Eldin and Zoula (1963) that young marine penaeid shrimps need an area of low salinity for their nursery grounds. Hoq et al. (2001) reported that the abundance of penaeid PL in the Sundarbans mangrove, Bangladesh was significantly correlated with temperature and salinity which also supports the present findings. The highest abundance of *Acetes* PL was observed in September and the lowest was in August. Deshmukh and Kagwade (1987) noted that in the Bombay harbour the highest abundance of *Acetes* PL was seen in December which is not similar with the present findings. This may be due to the different geographical location. Hoq et al. (2006) reported that the density of *Acetes* PL increases with salinity and temperature in the Sundarbans mangrove of Bangladesh which is similar to the present research, where there was a significant correlation with temperature. Highest abundance

of the *Lucifer* was observed throughout the year with the highest peak in July and the lowest in January. Zafar and Mahmood (1989) reported the highest occurrence of *Lucifer* in June, September to December and none occurred in January in the Bangladesh waters. Thus, the present findings are very similar to the findings of Zafar and Mahmood (1989).

Zafar and Mahmood (1989) also reported the occurrence of mysids throughout the sampling months in Bangladesh water; however it is different from the present study which records the highest density in the month of January and no catches in the month of August, September and February. However, continuous occurrence of shrimp post-larvae confirms the spontaneous spawning activity in this seagrass area.

Conclusion

The catches comprised of four major shrimp taxa namely: *Lucifer* (94.9%), *Acetes* (1.52%), *Penaeus* (0.13%) and *Mysis* (0.06%). Higher abundance of *Lucifer* compared to the other genus was observed throughout the year with peaks in the monsoon months (May to July and October to December). Peak abundance of the genus *Penaeus* was observed in June to July, although *Acetes* was found around the year with peak abundance in September. The occurrence of *Mysis* was also restricted only in the monsoon months (November to January and May to July). Significant correlation between the abundance of shrimp PL and environmental parameters was observed in the investigated area.

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