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Full Length Research Paper

Hydrobiological parameters, population density and distribution pattern in the gastropod *Nerita* (*dostia*) *crepidularia* Lamarck, 1822, from mangroves of Vellar estuary, Southeast India

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In the present study, the seasonal variation in physic-chemical parameters, population density and distribution pattern of *Nerita crepidularia* in the mangroves of Vellar estuary, Tamil Nadu was studied for a period of one year (January to December). The physico-chemical parameters such as temperature (atmospheric and water), pH, salinity, dissolved oxygen and rainfall were estimated. The atmospheric and water temperature ranged from 24 to 38 and 22 to 36°C, respectively. The pH ranged between 6.7 and 7.4. The dissolved oxygen was ranged from 4 to 5.1 ml/L. Salinity fluctuated between 4 and 38 ppt. The value of rainfall ranged between 240 and 6070 mm. Further the physic- chemical parameters in various seasons was subjected to analysis of covariance and was calculated as F = 3.055484 (P<0.05). Quadrate sampling was carried out monthly. The population density was found to be lesser (average 2 numbers / quadrate / 0.5 m^2) in monsoon (November, 2008) and higher (average 7 numbers / quadrate of 0.5 m^2) during post monsoon (February, 2008). Further the density of *Nerita crepidularia* in different seasons was subjected to analysis of covariance and was calculated as F = 0.0215 (P<0.05). In the present study, the correlation coefficients obtained between the population density and the hydrobiological parameters were non significant. This gastropod species is found enjoying a variety of habitats and interesting movement along the tides within the same mangroves. It is found attached to the mangrove plants on the stems and moving up and down along the tidal water, that is, during the high tide when the water level goes up to the height of 2.5 m above the ground level, the animals are also moving up and when the water level is coming down during the low tide, the animals are moving down along the tidal water. Further the animals are also found crawling in the intertidal muddy substratum during low tide.

Key words: Mangroves, physico-chemical parameters, *Nerita* (*Dostia*) *crepidularia*, population density, distribution pattern, Vellar estuary.

INTRODUCTION

Mangrove vegetation contributes to habitat complexity and the diversity of the associated fauna of the mangrove ecosystem (Hutchings and Saenger, 1987; Lee, 1998). The dominant macrofauna in terms of numbers and species are the crustaceans and molluscs (Sasekumar, 1974; Jones, 1984). These macrofauna form an important link between mangrove detritus at the base of the mangrove food web and consumers at higher trophic levels, which include birds and commercial fish species (Macintosh, 1984). Macrofauna also modify the mangrove's physical and vegetation structure through their burrowing activities (Smith et al., 1991) and by grazing on propagules, leaves and wood (Berry, 1972; Smith, 1987). Overall, molluscs play an important role in the ecological functioning of the mangrove ecosystem (Lee, 1998, 1999). Thus, their diversity and abundance may reflect the status and functioning of mangrove forest ecosystems and serve as potential biological/ecological

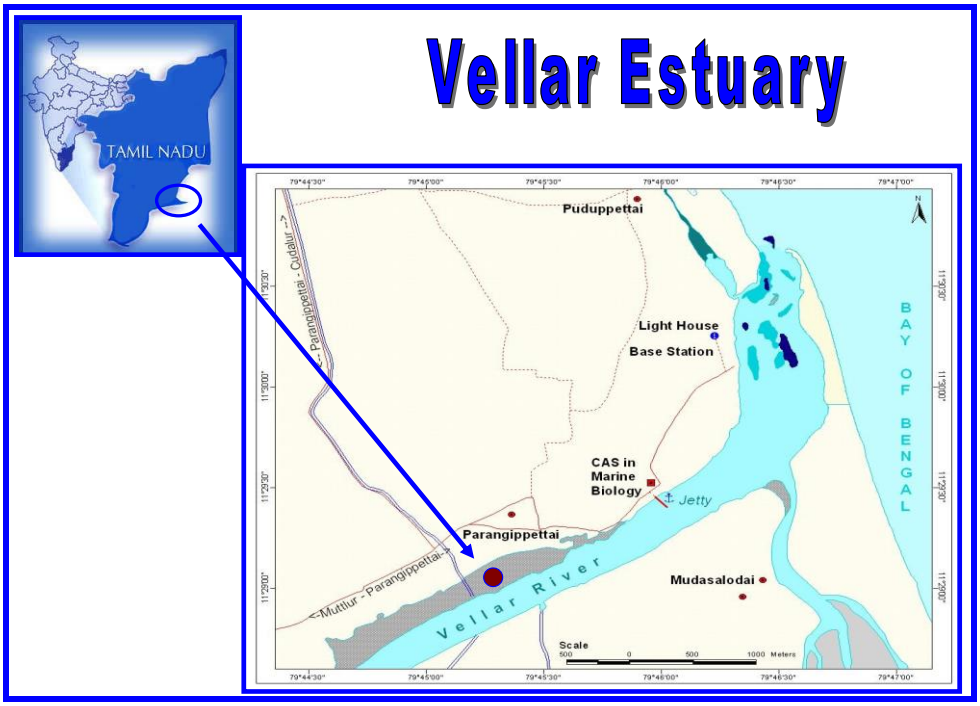

Figure 1. Study area.

indicators of habitat change in both natural and managed mangroves. However, very little information is available on the gastropod particularly neritids biodiversity of mangroves. Hence it is necessary to document the population density and distribution pattern of the *Nerita crepidularia* of threatened ecosystems.

MATERIALS AND METHODS

Physico-chemical parameters

Hydrobiological parameters (salinity, pH, atmospheric, ND surface water temperature, dissolved oxygen, rainfall) were studied monthly for a year from January to December, 2008 in mangroves of Vellar estuary (Figure 1), Southeast coast of India (Latitude N 11˚ 29.45' Longitude 79˚ 46.28'). The salinity was estimated using the refractometer (Model ERMA) and the hydrogen ion concentration (pH) was analyzed by using the pH pen (Model Hanna). The dissolved oxygen was estimated using the Digital DO meter (Model 831E). Atmospheric and surface water temperatures were recorded using a celsius thermometer. The rainfall data were obtained from the meteorological observatory unit located in our department (CAS in Marine Biology) which is run by the meteorological Department of the Government of India.

Method of collection

The snails (*N. crepidularia*) were collected monthly for one year from January to December (2008) at mangroves of Vellar estuary. For the quantitative analysis, the *N. crepidularia* were collected during low tide when the mud flats were exposed, by hand picking in a transect of known area (10 m in vertical and 20 m in horizontal) by using a quadrate covering an area of 0.5 m^2. An average of three quadrates was taken as mean value of the population. The arboreal forms were collected from the stems, roots and other parts of the mangrove trees vertically at every 25 cm height by hand picking (Sasekumar, 1974).

Statistical analysis

All the physico-chemical parameters and population density were treated statistically using MS office-Excel to understand the relationship between them by calculating correlation coefficient and analysis of co-variance (ANCOVA).

RESULTS

Physico-chemical parameters

Salinity

In the present study, salinity fluctuated between 4 and 38 ppt (January to December 2008). The highest salinity of 38 ppt was recorded in May 2008 (Summer season) and the lowest of 4 ppt, in December 2008 (Monsoon season) (Figure 2).

Hydrogen ion concentration (pH)

In this study, the pH ranged between 6.7 and 7.4. The maximum pH of 7.4 was recorded in the month of January and minimum pH of 6.7, in the month of December (2008) (Figure 3).

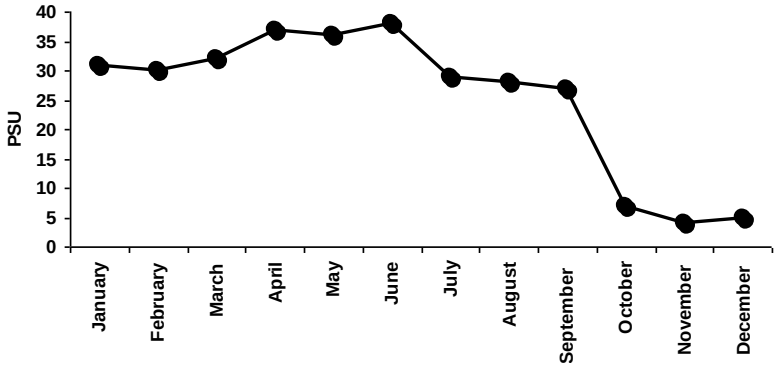

Figure 2. Salinity at different months.

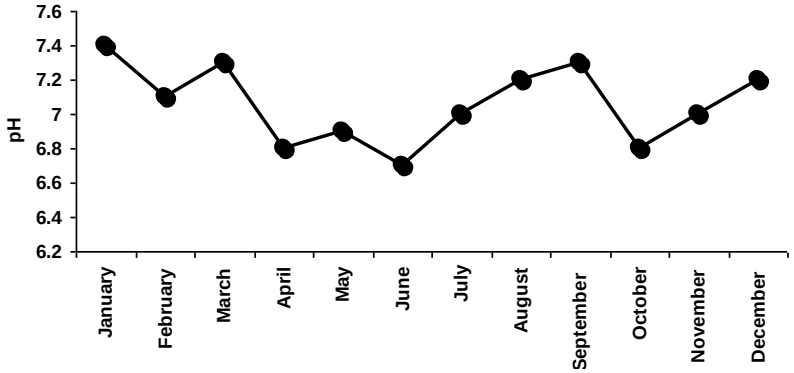

Figure 3. pH at different months.

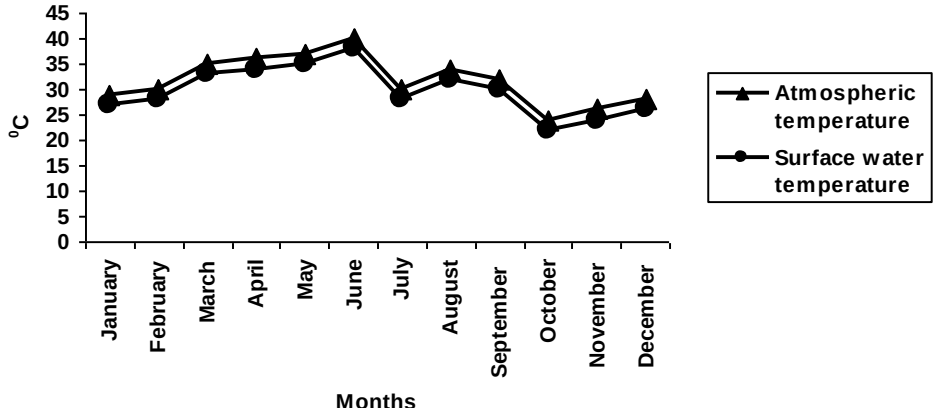

Figure 4. Atmospheric and surface water temperature at months.

Atmospheric and surface water temperature

The atmospheric and surface water temperature found varied from 24 to 38 and 22 to 36°C, respectively. The maximum atmospheric and surface water temperature (38 and 36°C) was recorded in the month of May (Summer) and minimum (24 and 22°C) in the month of November 2008 (Monsoon Season) (Figure 4).

Dissolved oxygen

The value of dissolved oxygen was reported to be ranging from 4 to 5.1 ml/L. The highest concentration of

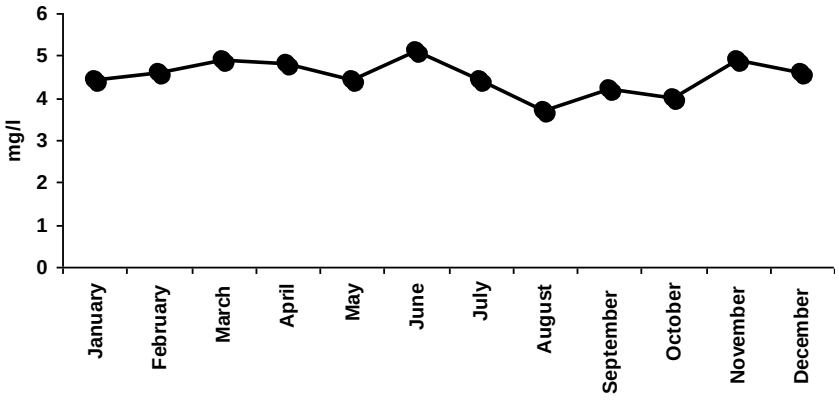

Figure 5. Dissolved oxygen at different months.

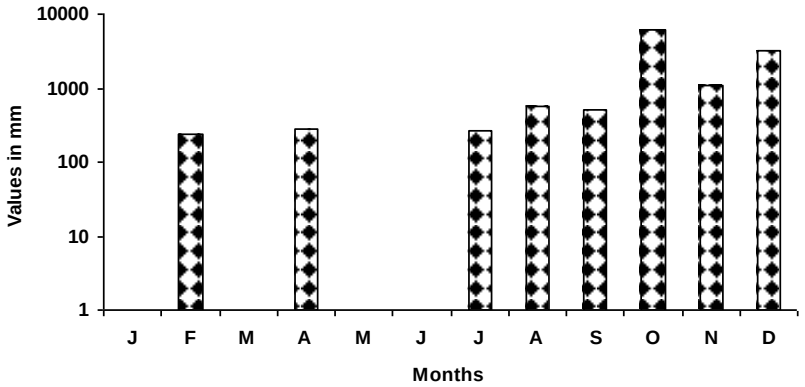

Figure 6. Rainfall in different months.

5.1 ml/L was recorded in the month of December (Monsoon season) and lowest concentration of 4 ml/L was recorded in the month of June 2008 (Summer season) (Figure 5).

Rainfall

The monthly total rainfall was reported to be ranging between 240 and 6070 mm. The highest value of rainfall (6070 mm) was recorded in the month of October and lowest (240 mm), in the month of February 2008. No rainfall was recorded in the months of January, March, May and June 2008 (Figure 6).

Population density

The population density was found to be minimum (average 2 numbers / quadrate of 0.5 m^2) in monsoon (November, 2008) and maximum (average 7 numbers / quadrate of 0.5 m^2) in post monsoon season (February, 2008). Further the density of *N. crepidularia* in various seasons was subjected to analysis of covariance and was calculated as F = 0.0215 (P<0.05) (Table 2). In the present study, the correlation coefficients obtained between the population density and the hydrobiological parameters were found significant at 0.05 level (Table 3), (Figure 7).

DISCUSSION

Physico-chemical parameters

Several studies on the physico-chemical properties of mangrove environment along the east coast of India have been carried out on salinity, dissolved oxygen and pH of water by many workers which include, Krishnamurthy and Prince (1981), Balasubramanian (1994), and Rajendran (1997) in Pitchavaram mangroves; Alagarsamy (1991) in Mandovi estuary; Bhaskara Rao et al. (1992) in Godavari estuary; Kathiresan et al. (1996, 2000) in Vellar estuary and Pitchavaram mangroves, and Palaniselvam (1998) in Pitchavaram mangroves. In this respect, the present investigation was attempted to study the physico-chemical variables of the mangrove environment in Vellar

estuary as this study is necessary to gain a holistic view of mangroves and their faunal component. Salinity acts as a limiting factor in the distribution of living organisms and its variation influence fauna in the intertidal zone (Gibson, 1982). Generally, changes in salinity in the brackishwater habitats such as estuaries, backwaters and mangroves are due to the influx of freshwater from land runoff caused by monsoon or by tidal variations.

The salinity recorded in the present study, 4 ppt (December 2008, Monsoon season) to 38 ppt (May 2008, Summer season) is comparable with that of 0 to 35 ppt in mangroves of Goa (Untawale and Parulaker, 1976), 2 to 24 ppt in Godavari estuary (Chandramohan, 1990), 1.02 to 31.0 ppt in Pitchavaram mangroves (Govindasamy and Kannan, 1991), 0 to 36 ppt in Kakinada mangroves (Selvam et al., 1992), 34 to 48 ppt in mangroves of Gulf of Kachchh (Vijayalakshmi et al., 1993) and 0 to 10 ppt in mangroves in Godavari estuary (Kesavan et al., 2007). In all the aforementioned, the salinity was found fluctuating widely which was mainly due to the influence of rainfall and influx of freshwater into the system. As a result, there was a more or less homogenous condition in the estuary with almost freshwater on top in monsoon and very low salinity. During the recovery phase (in the postmonsoon season), there was a marked reduction in freshwater discharge and the marine component began to occupy a greater part of the estuary. This resulted in the mixing of the small amount of freshwater flowing into the sea and saline water which entered into the estuary from the sea.

The pH of water may influence many biological and chemical processes in natural waters (Sreenivasan, 1974; Saad, 1978). But the pH values recorded presently did not show any definite seasonal pattern with the range of variations which were very narrow. Higher pH observed during postmonsoon could be ascribed to an increase in temperature and subsequent evaporation of water coupled with increased salinity (Zingde et al., 1987; Upadhaya, 1988). This could also be due to the removal of CO_2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, reduction of salinity and temperature and decomposition of organic matter as stated by Ragothaman and Patil (1995) and Upadhyay (1998). In the present study, the pH ranged from 6.7 (December) to 7.4 (January) in the mangroves along Vellar estuary. But in the mangroves at Pitchavaram, an acidic pH (with a pH range of 4.9 to 7.2) was reported by Govindasamy and Kannan (1991). But in Godavari mangroves, as also reported in the present study, the pH was reported mostly alkaline (6.4 to 8.2 in Godavari mangroves and 6.7 to 7.4 in the present study). Further, the pH of water (present study) was reported low during monsoon season that might be due to the freshwater inflow and decomposition of organic matter, as suggested by Zingde et al. (1987), Murugan and Ayyakkannu (1991) and Tiwari and Vijayalakshmi (1993).

Like salinity, the role of temperature for animal distribution in a particular area or niche is also well known. In brackishwater zone, the exclusion of certain species from areas with unsuitable temperature conditions is one of the major obvious effects of temperature on animal distribution (Choudhury et al., 1984). Less obvious are the effects of temperature on growth rates, length of life, reproductive capacity and intra and interspecific competition. In fact, such effect may have some impact, directly or indirectly, on the distribution of eurytherm species or communities (Choudhury et al., 1984; Parulekar et al., 1980).

In the present study, atmospheric temperature fluctuated between 24°C (November 2008) and 38°C (May 2008). The surface water temperature varied from 22 to 36°C during the study period. The highest value of surface water temperature (36°C) was recorded in May (Summer Season) and the lowest (22°C) in November (Monsoon Season). In the present study, summer peaks and monsoonal troughs in air and water temperature were noticed, as also observed earlier by several workers like Ragothaman and Reddy (1982), -20 and 38°C in Tapi estuary; Balakrishna and Abdual (1987), -17 to 36°C in Ashtamudi estuary; Desai (1992), -17 to 38°C in Gulf of Kachchh; Patra et al. (1990), -18 to 32°C in Mandarmani Canal mangroves in West Bengal; Selvam et al. (1992), -26.9 to 31.2°C (Water temperature) in mangroves along Kakinada coasts and Kesavan et al. (2007), -19 to 37 and 17 to 35°C (atmospheric and water temperature) in Godavari mangroves. Generally, surface water temperature is influenced by the intensity of solar radiation, evaporation, insulation, freshwater influx and cooling and mix up with ebb and flow from adjoining neritic waters. Qasim (1969) has also supplemented this fact by suggesting that the freshwater discharge alone was not responsible for the changes in temperature.

It is well known that temperature and salinity affect the dissolution of oxygen (Vijayakumar et al., 2000). In the present study, the values of dissolved oxygen ranged between 4 and 5.1 ml/L. The highest oxygen concentration of 5.1 ml/L was recorded in the month of December (Monsoon) and lowest of 4 ml/L, in the month of June (Summer season). Whereas the dissolved oxygen content varied widely as reported by Untawale and Parulekar (1976), 2.5 ml/L in May and 5.3 ml/L in October in mangroves of Goa; Govindasamy and Kannan (1991), 6 to 9.2 ml/L in Pitchavarammangroves; Selvam et al. (1992), 2.41 to 7.24 ml/L in mangroves located in Kakinada coast and Tripathy et al. (2005), 1.39 to 5.45 mgL^{-1} in Coringa river mangroves.

In the present study also, the dissolved oxygen content was influenced by water temperature for a greater extent and dissolved oxygen and temperature showed an inverse relationship as also observed by Vijayalakshmi et al. (1993).

Rainfall is the most important cyclic phenomenon in tropical countries as it brings about important changes in the hydrographical characteristics of the marine and

Table 1. Analysis of co-variance between the seasons in physico-chemical parameters.

ANOVA						
Source of variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Seasons	302.706	3	100.902	3.055484	0.069665	3.490295
Parameters	2634.637	4	658.6593	19.94532	3.1E-05	3.259167
Error	396.279	12	33.02325			
Total	3333.622	19				

Table 2. Analysis of co- variance between the seasons in *N. crepidularia.*

ANOVA						
Source of variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Rows	0.166667	2	0.083333	0.021583	0.978724	5.143253
Columns	139.5833	3	46.52778	12.05036	0.005962	4.757063
Error	23.16667	6	3.861111			
Total	162.9167	11				

Table 3. Correlation coefficient between the physico-chemical parameters and population density.

Parameter	**Population**	**Rainfall**	**Salinity**	**pH**	**AT**	**ST**	**DO**
Population	1						
Rainfall	-0.5145	1					
Salinity	0.7445	-0.7623	1				
pH	-0.0154*	-0.2263*	-0.0583*	1			
AT	0.5087	-0.6627	0.8327	-0.2367*	1		
ST	0.5087	-0.6627	0.8327	-0.2367*	1	1	
DO	0.2738	-0.3442	0.1466	-0.2667*	0.3109*	0.3109*	1

Significant at 0.05 level; * NS (Not significant).

estuarine environments. The rainfall in India is largely influenced by two monsoons viz., southwest monsoon on the west coast, northern and Northeastern India and by the northeast monsoon on the southeast coast (Govindasamy and Kannan, 1991). The rainfall during the present study period (January to December 2008) was reported to be ranging between 240 and 6070 mm. The highest rainfall (6070 mm) was recorded in the month of October and lowest (240 mm) in the month of February. No rainfall was recorded in the months of January, March, May and June 2008. Further the physic- chemical parameters in various seasons was subjected to analysis of covariance and was calculated as F = 3.055484 ($P<0.05$)
(Table 1).

Population density and distribution pattern

Gastropods in the Indo- Pacific region are fairly known. On culling information from various sources (Macnae, 1968; Sasekumar, 1974; Vermeij, 1974), it is seen that the gastropods in estuaries and mangals are represented by 27 families, 30 genera and 65 species. Hitherto the knowledge on Indo- West Pacific mangrove fauna was based on those from South African Madagascar and Malayan regions. Some of the families, namely, Littorinidae, Potamididae, Assimineidae, Ellobiidae and Onchidiidae have more representatives than other families in mangroves of the Indo- Pacific (Subba rao et al., 1995).

A number of gastropods are amphibious or semi-terrestrial and are capable of withstanding exposure to air. The snails belonging to the family Neritidae, which experience exposure during a large part of the day have a good representation in the mangroves. In the present study, the *N. crepidularia* was found surviving even for 3 days without exposure to water.

The distribution and relative abundance of *N. crepidularia* was not found uniform throughout the study period and was found to be decreasing in monsoon (November 2008) period (average 2 numbers / quadrate of 0.5 m^2) and increases during the post monsoon (February 2008) period (average 7 numbers / quadrate

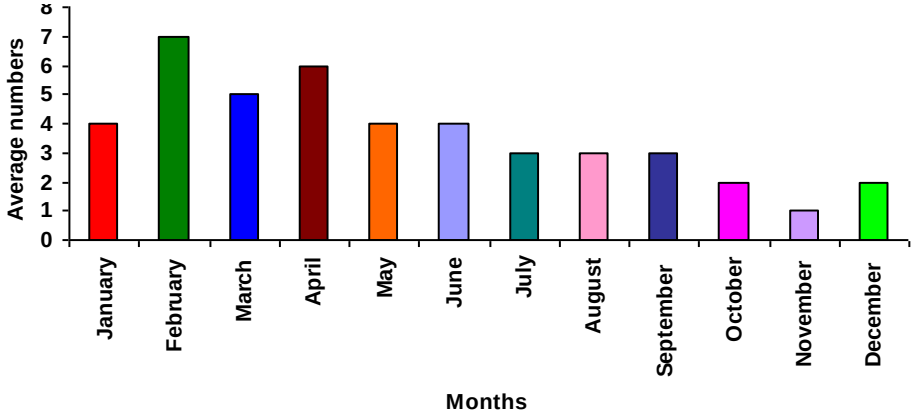

Figure 7. Population density in different months.

of 0.5 m^2). Kasinathan and Shanmugam (1985) studied the molluscan fauna in Pitchavaram mangroves and reported that rainfall, salinity and temperature had detectable effect on the distribution of the molluscs, where *N. crepidularia* were found in more numbers in relatively high saline areas when compared to the other areas recorded with low salinity.

The environmental framework in Hooker Bay restricts the molluscan community and its vigor. Wide fluctuations of dissolved oxygen and salinity, pollution by hydrocarbons and impacts generated by human activities were reported to be the reasons for such influence over the molluscan community (Ellison and Farnsworth, 1992). Another factor, the shrimp farming, also had a devastating effect on mangrove forests and the goods and services they support, such as fisheries and coastal protection (Primavera, 1993). In the present investigation also, the molluscan population in mangrove ecosystem under study receives stress through the dumping of domestic and municipal wastes and shrimp farming and fishing and human activities are also found influencing the molluscan population.

A majority of intertidal benthic fauna prefer such brackishwater situations where environmental conditions are markedly different from those of terrestrial and freshwater habitats. Animals in such habitats acquire a certain degree of euryhalinity conditions (Delamare and Deboutteville, 1960). Of all such factors, salinity is perhaps the most important one (Choudhury et al., 1984).

Although salinity seems to be a critical factor in the distribution of a number of molluscs, the nature of substratum has also a major influence on their occurrence in the estuary. Molluscs have adapted to estuarine conditions without osmoregulation. When the acclimatization is spread over a long period, the mollusc is able to withstand gradual reduction of salinities by appreciable levels (Panikkar, 1951).

Diversity of the molluscan communities associated with the red mangrove roots is high and the species richness increases with low variations of salinity and dissolved oxygen (Vilardy and Polania, 2002). In accordance with the aforementioned fact, in the present study, maximum number of molluscs was recorded in the postmonsoon season and minimum number, in monsoon season.

In the present study, the number of animals collected ranges from 2 to 7 numbers per quadrate of 0.5 m^2. In the earlier study, out of six species of gastropods recorded, *N. crepidularia* was an ubiquitous form when compared to other fauna collected from Pitchavaram mangroves (Kasinathan and Shanmugam, 1985). Macintosh et al. (2002) recorded thirty four molluscan species from Ranong mangrove ecosystem. Snails of the family Neritidae and Ellobiidae were the most abundant molluscs in the mature forests.

Further, the distribution of molluscs may not be based on any single hydrological parameters. The richness of fauna in tropical estuaries may be correlated with increased osmoregulatory ability in higher temperature (Panikkar, 1951). This is applicable more to the less motile estuary inhabiting organisms like molluscs. The percentage of organic carbon, dissolved oxygen, pH of water and nature of substratum were found to influence their distribution.

In the mangrove ecosystem the fauna are distributed both vertically and horizontally in a specific way. *L. melanostoma*, with a mantle cavity converted into a “lung” and the gill reduced, was found highest in the leaves, together with ants, spiders and lepidopteran caterpillars and was often above the level of high water of spring tides. Other species of *Littorina* occur slightly lower on the vegetation, while several gastropods were found on the level of the soil that was still lower, especially *Nerita* spp. The pulmo nates *Ellobium* and *Cassidula* occurred low on the stems and roots and presumably retained a lungful of air or retreated to air-filled niches when the tide submerged the shore (Berry, 1962).

In the present study, the *N. crepidularia* was recorded only up to mid tidal water marks. In the laboratory studies (Figure 11), the animals were found without stress up to 40 ppt, but above 40 ppt, the animals were lying on the

Figure 8. *N. crepidularia* found crawling on the mud.

Figure 9. *N. crepidularia* found attached to the oyster bed.

Figure 10. During high tide animal attached mangrove stem.

mud without any movement and also the animals got buried inside the mud (that is, 25% of the animal), which may be due to the stress imposed by higher salinity (Figure 12).

During monsoon season, the freshwater enters more in Vellar estuary above 2 m height; during this time, the animals are always found attached to the mangrove trees up to 2 m height even during low tide; also, since the water is not fully drained out and thus, by this time the neritids are facing trouble for feeding.

Further, the molluscan diversity is determined by the availability of microhabitats providing shelter and feeding grounds. In mangrove ecosystem, the roots lacked mobile individuals because they did not have shelter or habitat potential. Naked roots remain, most of the time, free of mobile individuals, although they may become optimal ground for larvae and lead to the colonization and establishment of attached communities (Wahl, 1989).

N. crepidularia is found enjoying a variety of habitats and interesting movement along the tides within the same mangrove area. It is found attached to the mangrove plants on the stems and moving up and down along the tidal water, that is, during the high tide when the water level goes up to the height of 2.5 m, the animals are also moving up and when the water level is coming down during the low tide, the animals are moving down along the tidal water (Figure 10). Further the animals are also found crawling in the intertidal muddy substratum during low tide (Figure 8). In this area, oyster bed occupied fully near the mangrove stretch; the *N. crepidularia* are found attached to inside the oyster bed also (Figure 9). Another interesting observation on *N. crepidularia* is its most occurrences at the edge of water which may be for feeding on the microalgae present there as also observed in the case of *N. albicella* (Govindan, 1972).

In the present study, correlation coefficient was calculated between the physico- chemical parameters and population density. The population density was negatively correlated with rainfall ($r = -0.5145$, $P>0.05$) and pH ($r = -0.0154$, $P>0.05$). It was positively correlated with salinity ($r = 0.7445$, $P<0.05$), atmospheric temperature ($r = 0.5087$, $P<0.05$), surface water temperature ($r = 0.5087$, $P<0.05$) and dissolved oxygen ($r =0.2738$, $P<0.05$).

Conclusion

This archaeogastropod *N. crepidularia* is found enjoying a variety of habitats and interesting movement along the tides and also it is found attached on to the mangrove plants on the stems and moving up and down along the tidal water. Further, the animals are also found crawling in the intertidal muddy substratum during low tide. Assessment of the abundance and species richness of Neritid as well as other mangrove molluscs, using a hierarchical sampling approach is therefore, needed when investing the biodiversity of mangrove habitats and

Figure 11. During laboratory experiment.

Figure 12. During semidry condition, 25% of the animal inside the mud.

conservation value of these threatened environment.

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