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Distribution and Zonation Patterns of *Cerithideopsilla cingulata* (Gmelin 1791) (Gastropoda: Potamididae) in Mangrove Stands at Sandspit Backwater, Karachi, Pakistan

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Abstract.- Mangroves create distinctive ecological environments that are characterized by a significant biodiversity which provides food and shelter to a variety of organisms. Gastropods are the largest and most diverse class of mollusc. To assess the seasonal variation in distribution and abundance of *Cerithideopsilla cingulata* sampling was conducted during July, October 2002 and January, April 2003, respectively in mangrove stands, at Sandspit backwater. A total of 14 core samples were collected from rhizosphere (7 cores) and non-rhizosphere (7 cores). Four cores from each site were used for biomass analysis and the remaining three cores were used for sediment analysis. The top 10 cm of each core was sliced at 1 cm interval and each layer was sieved through 1 mm^2 mesh. Live *C cingulata* were sorted, counted and weighed (wet). For sediment analysis, cores were treated in the same manner for the determination of water content, organic and inorganic matter. We observed a seasonal variation in total number of *C cingulata* and the density also varied between two sites. The non-rhizosphere is found to be most productive in terms of number of *C. cingulata.* During the period between January to April *C. cingulata* are more abundant. Their number ranges from 185-214 individuals/m^2 in non rhizosphere and 115-119 individuals/m^2 in rhizosphere, respectively. Pearson correlation showed that the *C. cingulata* numbers were positively correlated to the concentration of inorganic matter in the sediment and were negatively correlated in terms of deregulated distribution of sedimentary organic matter. Our data will help understand the ecological niches preferred by *C. cingulata* in mangrove sites.

Key words: *Cerithideopsilla cingulata Avicennia marina*, mangrove, Pakistan, gastropod, distribution, abundance.

INTRODUCTION

Distinct ecological environments created by mangrove stands are characterized by a significant biodiversity. They offer wide variety of niches (mangrove barks, leaves, roots (pneumatophore), dead wood, water pool and muddy or sandy sediments) for animals inhabiting mangrove ecosystem. These organisms play important role in the food web, nutrient cycling and overall energy-flux of mangrove ecosystems (Odum and Heald, 1972; Schwamborn, 1997; Kathiresan and Bingham, 2001). The distribution of these organisms is generally affected by several factors, including the physical environment (*e.g.*, temperature, salinity, pH, and Oxygen level etc.), animal-sediment relationship as well as species interaction (Reise, 1985; Blaber and Milton, 1990**;** Burney and Barkati, 1995**).** Benthic fauna also follows a zonation of varying environmental conditions from the high towards the low tidal levels, corresponding with certain changes in sediment properties, wave exposure and duration of submergence and exposure (Barkati and Burney, 1995; Dittmann, 1995**;** Blanco and Cantera, 1999; Dittmann, 2002).

Mollusca and Arthropoda have been reported to be the most abundant and diverse groups of organisms (Malley, 1977; Wells, 1984; Robertson and Duke, 1987; Barakati and Tirmizi, 1990; Guerreiro *et al.*, 1996). The largest shelled mollusk is a bivalve: *Tridacna gigas* can grow up to 1 m length (Yan *et al*., 2013), while gastropods are the most species rich class of mollusc. Mangroves provide ideal conditions for higher productivity of gastropods which in turn, serve as food, for numerous other animals (Bourgantzani and Zenetos, 1983; Jiang and Li, 1995; Dittmann, 2002). In Pakistan, a few studies were undertaken on the population dynamics, species composition, distribution and biomass estimation of benthic fauna

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(Ahmed *et al.*, 1982; Ahmed and Ayub, 1999; Siddiqui and Farooq, 2000; Hameed and Ahmed, 2002; Barkati and Rehman, 2005; Rehman and Barkati, 2012; Afsar *et al.*, 2012). Among gastropod fauna *Cerithideopsilla cingulata* (Gmelin, 1791) appears to be the most abundant and yet assessment of their distribution and abundance in a sediment column with respect to depth is still unknown. It is a herbivorous/ detritivorous organism. Owing to its role as a putative consumer of algal and mangrove detritus matter, assessment, abundance and distribution of *C. cingulata* has become an exceedingly important task and it would be of great ecological significance as well. Therefore the objective of our present study was to determine the vertical and horizontal distribution as well as abundance of *C. cingulata* in rhizosphere and non-rhizosphere areas of mangrove at Sandspit backwaters, Karachi, Pakistan. The obtained data will also help to understand the ecological niches that this gastropod would prefer in mangrove ecosystem and its behavioral response to seasonal and other physico-chemical parameters respectively.

MATERIALS AND METHODS

Sampling area

The sampling was performed at two stations, inside (rhizosphere) and outside (non-rhizosphere) mangrove stands, at Sandspit backwater on quarterly basis in July, October 2002 and January, April 2003. Collection was done during low tide so that the maximum part of the exposed study area will be examined. Physical parameters including tidal level, air, water and mud temperature, salinity, pH and dissolved oxygen were observed (Table I).

Cerithideopsilla cingulata collection

Distribution and abundance of *Cerithideopsilla cingulata* was assessed by using corer. Seven cores (7.5 cm diameter) were taken randomly from two sites, rhizosphere and non-rhizosphere each. Four cores were used for analyzing *C. cingulata* distribution and biomass and three for sediment analysis. Core samples were sectioned into 1 cm layers (from 1-10 cm depth). The sample of each layer was washed through 1 mm^2 mesh sieve and transferred in polythene bags. Once in the laboratory, samples were washed with distilled water to remove adhering extra material and organism were counted and sorted into live and dead animals. Tissues of live animals were extracted and analyzed for organic and inorganic content (Horwitz, 1975).

Sediment analysis

For the analysis, core sample were sliced in the above mentioned manner. Samples of each layer were analyzed for water content, organic and inorganic matter (Horwitz, 1975).

Statistical analysis

Statistical analyses were carried out using Minitab 11.12 (version). Pearson Correlation coefficient was used to determine the relationship between density of *C. cingulata* versus concentration of organic and inorganic matter.

RESULTS

The data for both distribution and abundance of *Cerithideopsilla cingulata* in the rhizosphere and non-rhizosphere (Fig. 1) showed seasonal variation (Fig. 2). Density of *C. cingulata* decreases with depth (vertical distribution) at both sites (Fig.2). Higher density of organisms were observed on the surface sediment throughout the year. They were comparatively less abundant on the surface in October and showed highest density in April. Rhizosphere always had less mean numbers (100 individuals/m^2) as compared to non-rhizosphere (150 individuals/m^2) (Table II).

Table III showed a distinct seasonal variation in the size range of *C. cingulata*, in terms of organic and inorganic content of animals collected from rhizosphere and non-rhizosphere. We also observed that, the size of the organisms was smaller in July and October but larger in April. As for density, the biomass of gastropod was lowest in October and highest in April in both rhizosphere and non-rhizosphere. *C. cingulata* contributes between 17 and 119 g of organic matter in a square meter of surface sediments.

Percent organic matter was higher in in sediment samples from rhizosphere as compared to non-rhizosphere and the organic content increases with depth at both stations. The percent inorganic matter at both stations showed highest value on the

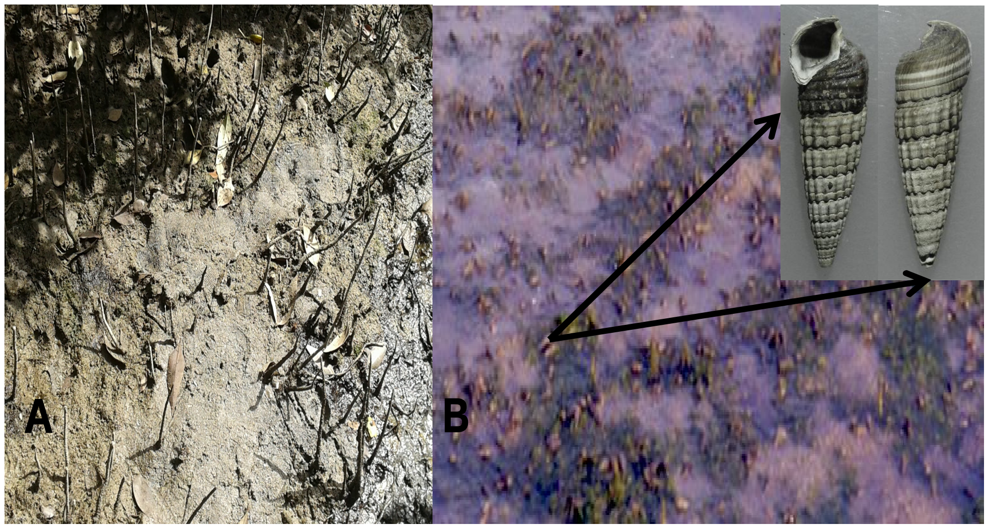

Fig. 1. Study site (A) rhizosphere and (B) non-rhizosphere showing abundance of *C. cingulata.*

Table I.- Seasonal variation of physico-chemical parameters of channel water at Sandspit.

Months	Tidal height feet	Temperature (°C)			Salinity $^0/_{00}$	pH	Dissolved oxygen mg O_2/l
		Air	Water	Sediment			
July	0.6	36.5	35.23	34	45	7.65	0.6
October	1.1	27	25	23.9	41	6.88	1.65
January	0.2	22	20.6	20.4	36	6.36	1.89
April	0.5	27.5	26	27.45	42	6.54	1.62

Table II.- Seasonal variation in abundance and distribution of *Cerithideopsilla cingulata* in the sediment surface at Sandspit.

Location in mangrove ecosystem	Distribution of *C. cingulata*/m^2				
	July	October	January	April	Average
Non Rhizosphere	131	71	185	214	150
Rhizosphere	98	67	119	115	100

surface layer. The amount of inorganic matter decreases with depth at both stations (Fig. 3). The density of *C. cingulata* showed positive correlation with inorganic matter and negative correlation with organic matter in the sediment (Table IV) respectively.

DISCUSSION

Cerithideopsilla cingulata is one of the most abundant species generally occurring in the sediments of mangrove swamps including mangrove stands at Sandspit backwater. It belongs to class Gastropoda and is a year round breeder (Ahmed, 1980). It is now evident that *C. cingulata* consumes mangrove detritus, an important component of the mangrove detrital food chain (Flores-Verdugo *et al.*, 1987; Pitiwing, 2000). The assessment of its distribution and abundance in mangrove forest was therefore considered significant. The density (individual/m^2) varies with respect to seasons depth of sediment column. In the present study, higher numbers of *C. cingulata* were recorded in January and April and moderate to low in July and October,

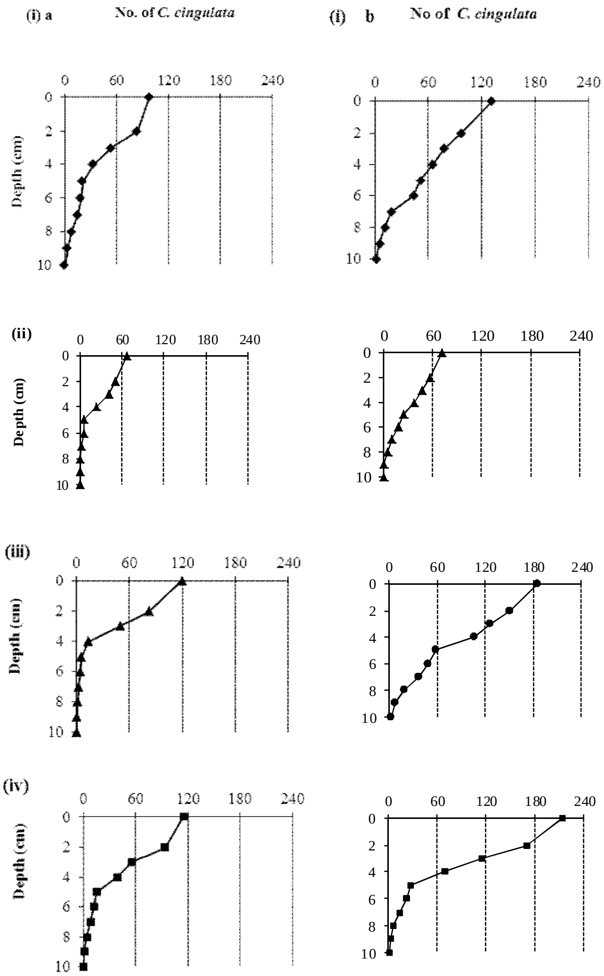

Fig. 2. Vertical density distribution of *Cerithideopsilla cingulata* in the sediment of (a) non-rhizosphere and (b) rhizosphere during (i) July (ii) October (iii) January and (iv) April.

which is in agreement with earlier studies conducted by Price *et al.* (1987) and Khan *et al.* (1999). These authors did not examine the differences in numbers of *C. cingulata* with location in mangrove swamps such as rhizosphere and non-rhizosphere. Non-rhizosphere had higher density of C. *cingulata* during January (185 individual/m^2) and April (214 individual/m^2) as compared to rhizosphere (119 individual/m^2 for January and 115 individual/m^2 for April). This may be attributed to the presence of algal mats (macro-algae, micro-algae and cyanobacteria) on the exposed mud flats (non-rhizosphere). Microalgae has higher nutritional value having distinctly low C:N ratio compared to

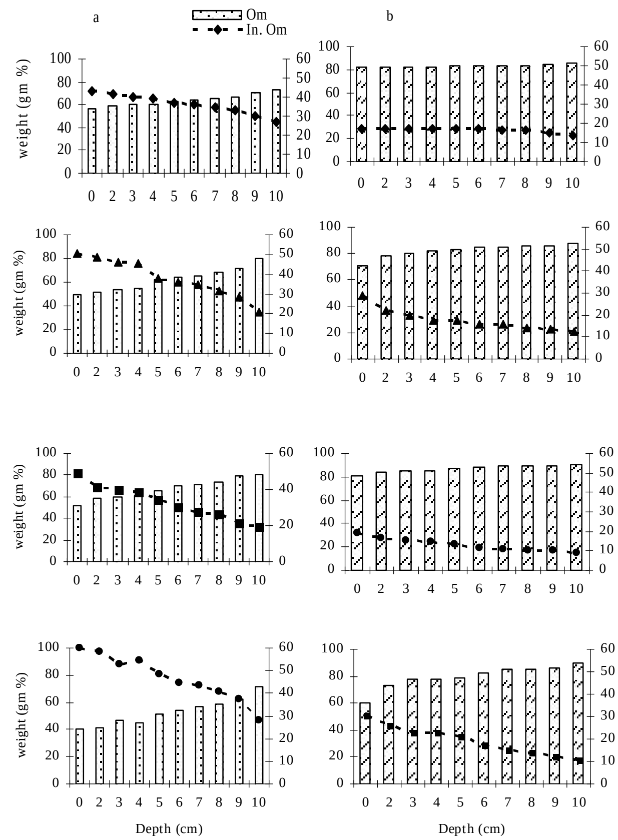

Fig. 3. Concentration of organic and inorganic matter in the sediment column (depth 1-10 cm) in a: non-rhizosphere and b: rhizosphere during (i) July (ii) October (iii) January and (iv) April.

Table III.- Seasonal variation in organic and inorganic matter of *Cerithideopsilla cingulata* inhabiting mangrove rhizosphere and non- rhizosphere at Sandspit backwaters.

Months	Size range (cm)	Inorganic matter (g/m^2)	Organic matter (g/m^2)
Rhizosphere			
July	0.9-1.3	36 ± 4	28 ± 1.52
October	0.7-1.1	25 ± 4	16.7± 0.90
January	0.8-1.7	62 ± 2.08	38 ± 3.78
April	1.4-2.6	88 ± 6.65	38.9 ± 2.12
Non-rhizosphere			
July	0.7-1.4	51 ± 7.07	26 ± 1.52
October	0.9-1.5	37 ± 8.88	21 ± 1.52
January	1.0-1.7	180 ± 2.08	111 ± 2.51
April	1.5-2.7	186 ± 4.58	119 ± 2.08

Table IV.- Pearson correlation coefficient matrix showing relationship between number of *Cerithideopsilla cingulata* with concentration of organic and inorganic matter in the sediment of rhizosphere and non-rhizosphere during 1 January 2 April 3 July and 4 October.

	CC1	Om1	I Om 1	CC2	Om2	I Om 2	CC3	Om3	I Om 3	CC4	Om4
Rhizosphere											
Om1	-0.835										
I Om 1	0.742**	-0.975									
CC2	0.95	-0.651	0.531*								
Om2	-0.951	0.733	-0.587	-0.952							
I Om 2	0.95***	-0.74	0.594	0.948***	-0.999						
CC3	0.894	-0.573	0.427	0.973	-0.959	0.956***					
Om3	-0.992	0.803	-0.696	-0.955	0.961	-0.958	-0.902				
I Om 3	0.993***	-0.8	0.694	0.955***	-0.96	0.957	0.901***	-0.999			
CC4	0.95	-0.666	0.543*	0.991	-0.963	0.96***	0.98	-0.956	0.955***		
Om4	-0.946	0.763	-0.617	-0.926	0.993	-0.992	-0.927	0.962	-0.959	-0.941	
I Om 4	0.99***	-0.861	0.764	0.919***	-0.951	0.948	0.868	-0.99	0.989	0.93***	-0.961
Non-rhizosphere											
Om1	-0.939										
I Om 1	0.939***	-0.1									
CC2	0.993	-0.936	0.936***								
Om2	-0.931	0.988	-0.989	-0.94							
I Om 2	0.934***	-0.989	0.989	0.944***	-0.1						
CC3	0.986	-0.937	0.937***	0.998	-0.974	0.951***					
Om3	-0.976	0.979	-0.979	-0.977	0.972	-0.974	-0.975				
I Om 3	0.977***	-0.981	0.981	0.977***	-0.974	0.976	0.974***	-0.999			
CC4	0.958	-0.845	0.845**	0.97	-0.86	0.864**	0.97	-0.908	0.906***		
Om4	-0.954	0.987	-0.987	-0.927	0.994	-0.994	-0.931	0.963	-0.966	-0.845	
I Om 4	0.925***	-0.986	0.985	0.929***	-0.995	0.995	0.934***	-0.965	0.968	0.847**	-0.1

***= Significant at $p<0.001$

CC, *Cerithideopsilla cingulata*; Om, Organic matter; IOm, Inorganic matter.

mangrove tissues (Hemminga *et al.,* 1994; Shafique *et al*., 2015). It has been demonstrated that the relative importance of different food items for a certain species can vary by its location and that such difference in diet composition may be related to the availability of different potential food sources (Bouillon *et al.,* 2004; Doi *et al.,* 2005). Also, the time of the year (January to April) when *C. cingulata* had high density coincides with the algal bloom and appearance of mats on surface mangrove sediments (Saifullah and Elahi, 1992; Chaghtai and Saifullah, 1992 and personal observation). The number of *C. cingulata* has positive correlation with inorganic matter in the sediment of rhizosphere and non-rhizosphere and negatively correlated with organic matter. The presence of a large number of these gastropods in rhizosphere indicates that they may be consuming mangrove detritus. *C. cingulata* has been reported to prefer decomposed mangrove litter (Shafique 2006). It may be concluded that *C. cingulata* showed seasonal pattern in their distribution and abundance in sediment column at both rhizosphere and non-rhizosphere and that their density decreases with depth.

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