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Species Diversity, Distribution and Seasonal Abundance in Mangrove Associated Molluscs along the Karachi Coast, Pakistan

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SPECIES DIVERSITY, DISTRIBUTION AND SEASONAL ABUNDANCE IN MANGROVE ASSOCIATED MOLLUSCS ALONG THE KARACHI COAST, PAKISTAN

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ABSTRACT

Mangrove or Mangal vegetation are typical wetland ecosystems found in coastal deposits of mud and silt throughout the tropics and some distance into the sub-tropical latitude. Species diversity, distribution, seasonal abundance in population and behavioral responses of mangrove associated molluscs (gastropods and bivalves) were investigated in two mangal areas: Sandspit and Korangi, along the Karachi coast of Pakistan. For sampling, a fixed route was followed throughout the study period and the samples were collected and observations were made from HTZ to LTZ. Fourteen species of molluscs (5 Prosobranchia; 6 Pulmonata; 1 Opisthobranchia and 2 Lamellibranchia) belonging to ten families were recorded. Family Ellobiidae, Potamididae, and Onchididae were found extensively distributed in both sites. All the recorded species are belonging to the epifaunal mode of life. Analysis of the data shows that ten of the recorded species are common to both sites, while four are exclusively found at the Korangi site. Seven of the representative species are exclusively mangrove associated; five are common to mangrove and non-mangrove areas, while two are non-mangrove dwellers. The low species diversity can be attributed either to the study techniques, a small number of study sites or possibly to the geographical locations of the study sites. Seasonal variations were noticed in species diversity and density distribution, indicating higher values in summer and autumn and lower in spring and winter.

Keywords: Mangroves, Molluscs, Karachi, Pakistan, Wetland ecosystem.

INTRODUCTION

Mangrove or Mangal vegetation are typical wetland ecosystems found in coastal deposits of mud and silt throughout the tropics and some distance into the sub-tropical latitude. The best suitable area for their growth is the sea-land interface, where the saline water mixes with fresh water. In Pakistan, the mangrove plant is locally known as “Timer”. These forests cover about 617,470 hectare in the Indus delta (Vistro, 1999). These wetlands provide both hatching as well as nursery grounds for a large number of commercially important fish and shell fish species. The intricate root systems of mangrove plants provide a habitat for a number of benthic organisms like algae, molluscs, polychaetes, crabs, bryozoans, etc., which all require a hard substratum for anchoring while they filter feed and help to impede water flow, thereby enhancing the deposition of sediment in areas where it is already occurring.

In the mangrove ecosystem, few animals feed directly on the living trees; however, the deposit in the sediments from mangal leaves, stem, flowers, etc., gradually decompose due to the physical and microbial action, which makes up the basis of the detritus food web (Day, 1975; Evink, 1975). Marine invertebrates are considered an important link between the initial detritus at the bases of the food web and the terminal consumers (Coull *et al.,* 1995). The information regarding the role of invertebrates in the mangrove ecosystem are quite scanty, however. Molluscs and crustaceans are important components of the ecosystem (Jiang and Li, 1995; Wells, 1983, 1990; Milward, 1982; Redfield, 1982). Muddy sands to sands and beachrock are the predominating benthic habitats. The important ecosystem engineers are the oyster *Saccostrea cucullata*, which forms decimeter- to meter-scale bioherms in the lower intertidal, the ocypodid crab *Dotilla sulcata*, which reaches highest abundances on the tidal flat, some tens of meters from the low-tide line, and the callianassid decapod *Paratrypaea bouvieri*, which is very abundant in the subtidal (Zuschin and Ebner, 2015).

The herbivorous molluscs play the role of primary consumers in the trophic levels of the mangrove ecosystem, being the grazer or suspension feeders. These gastropods and bivalves are exposed to large numbers of predators, some of whom depend entirely upon these molluscs for their survival. Malacophagous predators include fish, birds and mammals and the molluscs thus play an important role in the complex food web of the mangrove ecosystem (Chaudhuri and Chaudhury, 1994).

Keeping in view the immense value of molluscs in the mangrove ecosystem, a number of studies have been performed throughout the world on the ecological relationships of mangroves and molluscs (Suresh *et al.,* 2012; Venkatesan *et al.,* 2010; Kesavan *et al.,* 2009; Shanmugam and Vairamani, 2009; Dey 2006; Ingole *et al.,* 2002; Pereira *et al.,* 2002; George 1995; Jiang and Li 1995; Britton, and McMahon, 1990; Das and Roy 1989; Peckol *et al*., 1989; Little 1989; Fairweather 1988; Price *et al*., 1987; Reid 1986; Gao and Li 1985; Shokita *et al.,* 1985; Mandal and Misra, 1985; Centraet *et al.,* 1983; Morton and Morton 1983; Takenouchi 1983; Wells 1983, 1984, 1985, 1986 and 1990; Chambers 1980; Yipp 1982; Petraitis 1982;).

At the regional level, the mangrove flora received due attention and is therefore well documented. On the contrary, the mangrove fauna, particularly the molluscan fauna, is not paid due attention and is therefore poorly known. An increase of species density and diversity in the Post monsoon season was highest at 2 locations of Pondicherry mangroves whereas lowest was observed in fine sand locations dominated by few gastropods (Satheeshkumar and Khan, 2012). Aneiros *et al.,* (2014) investigated seasonal variations using univariate faunal parameters and functional groups, and correlated with those in sediment features and sediment heterogeneity to explain diversity of the assemblages. The results of Samidurai *et al.,* (2011), implied that the different mangrove ecosystem had different effects on the macrofauna communities and shed light on the macrofauna adaptation capability to specific habitats. Saifullah (1982) mentioned the occurrence of some molluscs in the Indus mangroves. Tirmizi and Barkati (1983 a, b; 1988) shed some light on the occurrence of molluscs in the mangrove area

of the Karachi coast. Barkati and Rahman (2005) investigated the benthic fauna of Sindh mangroves and found that five species of molluscs (*Cerithidea cingulatus, Natica lamarckii, N. didyma, Nodilittorina leucostica* and *N. picta*) were regularly found in abundance. However, no detailed work has been carried out on the species diversity, distribution pattern and seasonal variations on mangrove-associated molluscs. Therefore, the present work will not only help to bridge the gap at the regional level but will also provide valuable information on molluscan species composition and diversity for comparison in similar ecosystems elsewhere.

MATERIAL AND METHODS

Mangrove associated molluscs were investigated in two mangal areas: Sandspit (24° 48'N, 66° 59'E) and Korangi (24° 48'N, 67° 13'E) along the Karachi coast, Pakistan. The study site at Sandspit was located within the mangrove habitat, representing the backwaters of Karachi harbor. It forms the western most part of the Indus delta mangroves ecosystem, while, the study site at Korangi was bounded on either side by Korangi creeks and situated opposite to the Korangi fish harbor. Geographically, the site is located in the northern creek mangroves of the Indus delta.

For sampling, each site was regularly visited during low tide at monthly intervals from March 2011 to February 2012. The two sites were thoroughly investigated for molluscan diversity and their distribution pattern. Wherever possible, observations on behavioral responses of the individuals have also been incorporated in the study. At each mangal area, a long transect of approximately 180 meters of length was laid from the seaward edge to landward. At each transect, three sampling stations were established with the first in the Low Tide Zone (LTZ) at the seaward edge, while the second (Mid Tide Zone: MTZ) and third (High Tide Zone: HTZ) stations were located at equal intervals within the mangroves facing the landward edge. At each station, fifteen quadrates (each 1 m^2) were randomly laid on either side of the transect.

For sampling, a fixed route was followed throughout the study period and the samples were collected and observations were made from HTZ to LTZ. The samples were labeled and habitat notes were made in the field. The epifaunal samples were simply picked up by hand and collected in plastic bags, while for the infaunal samples, sediment samples were obtained through sand corer. The core samples were taken from a depth of 12 cm. Three replicates were made for each station. In a laboratory, the sediment was passed through a brass sieve (0.8 mm mesh size). Individuals collected were preserved in 70% alcohol. The molluscan friction is studied in detail and only live samples were used in subsequent analysis.

On the basis of the literature concerned and subsequent field investigations, epifaunal macro molluscs *Telescopium telescopium, Cerithidium cingulatus,* and *Onchidium* species were observed as the predominant and permanent dwellers of the two study sites .Therefore, these species were selected for comprehensive studies, only because of their abundance to work with quantitatively.

The various physiochemical parameters like salinity, pH, and temperature were recorded at each station to study their possible effect on the local

distribution of molluscan species. Impact of the tidal effect was also investigated with reference to species distribution. Whenever possible, population dynamics of molluscan assemblages were compared both before and after low tide.

RESULTS

Species Diversity and Distribution

Fourteen molluscs species were collected in the two mangroves area surveyed (Table 1). The molluscan component in the mangrove zone was primarily epifaunal in their life habits. The Prosobranchia, Pulmonata, Opisthobranchia and Bivalvia are accounting for 80.13%, 5.84%, 0.02% and 13.9% of the total species respectively.

The molluscan fauna was mainly composed of near shore euryhalinous species including *Salinator fragilis, Clypeomorus bifasciatum, Melampus taeniolatus, Ellobium opportunatum, Melampuscas taneus, Littorina undulate, Onhidium sp., Telescopium telescopium, Cerithidea cingulatus,* and *Haminoe exarata*. Estuarine low salinity species e.g. *Turbo coronatus, Cymia carinifera, Crassostrea gryphoides,* and *Crassostrea madrasensis* were mostly found at Korangi in the regions where comparatively low salinity was recorded.

Family Ellobiidae (3 spp.), Potamididae (2 spp.), Onchididae (1 spp.), and Opisthobranch (1 spp.) were found extensively distributed in the study area. Ten species were recorded common to both sites, while four species were exclusively found at the Korangi site. Among the collected species, eight were found to be mangrove associated, five were common to both mangrove and non-mangrove areas, and two species were non mangrove in nature (Table 1).

Cerithidea cingulatus, Telescopium telescopium and *Onchidium sp.* were the abundant species at both sites and constitute 84.7% of the total species. Due to their abundance, these species were only selected for quantitative studies. The data also established that the population density of the abundant species varies widely both within and between the two investigated sites. Annual mean density of *Cerithidea cingulatus* for Sandspit was 127 individuals/m^2 while 83 individuals/m^2 were recorded at Korangi. For *Telescopium telescopium* it was 1.25 and 1.41 individuals/m^2 at Sandspit and Korangi respectively, however, extreme variations were noted in the population density of *Onchidium sp*. Mean annual density for Korangi was 12 individual/m^2 and only 1/m^2 was recorded for Sandspit.

Abundance Distribution and Seasonal Variations

Density of molluscs in the surveying area was high, with the annual mean of 146 and 103 individuals/m^2 at Sandspit and Korangi respectively. The data showed that at both sites the density was high in autumn (September, October, November) and summer (May, June, July, August) than in spring (March, April) and winter (December, January, February). Seasonal variations were much pronounced for the dominant species both within and between the two sites. Highest population density for *Cerithidea cingulatus* was recorded at Sandspit (172 individuals/m^2) and Korangi (120 individuals/m^2) in the autumn. Whereas the lowest density was observed in spring

with 53 and 25 individuals at Sandspit and Korangi respectively.

Table 1: List of Molluscs found in the Mangrove areas of Sandspit and Korangi along the Karachi Coast Pakistan

Classification	Identified From
Class: Gastropoda Sub-class: Prosobrancia Order: Archaeogastropoda Family: Turbinidae	
Turbo (Lunella) *coronatus*	Zehra (1984)
Order: Mesogastropoda Family: Potamididae	
Telescopium telescopium	Zehra (1981)
Cerithidea cingulatus	Kira (1962)
Family: Cerithidae	
Clypeomorus bifasciatum	Dance (1974)
Family: Littorinidae	
Littorina undulate Gray	
Order: Neogastropoda Family: Thaididae	
Cymia carinifera	Zehra (1981)
Sub-class: Opisthobranchia Family: Haminoeidae	
Haminoe exarata	Gosliner (personal communication)*
Sub-class: Pulmonata Order: Basommatophora Family: Ellobiidae	
Melampus teaniolates (Hombron&Jacquinot)	Habe (1964)
Ellobium opportunatum (Gould)	Habe (1964)
Melampus castaneus (Muhlfeld)	Bosh *et al*. (1995)
Family: Amphibolidae	
Salinator fragilis (Lamarck)	Bosh *et al*. (1995)
Order: Systellommatophora Family: Onchididae	
Onhidium sp.	Gosliner (personal communication)*
Class: Bivalvia Family: Ostreidae	
Crassostrea madrasensis (Preston)	Siddiqui (1998)
Crassostrea gryphoides (Schlotheim)	Siddiqui (1998)

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Telescopium telescopium was found at both sites throughout the year with less seasonal variations. However, the maximum density (1.6 individuals/m^2) was observed in summer at both sites.

Significant differences were noticed in the population density and seasonal abundance of *Onhidium* sp. at both sites. At Korangi, the maximum density (23 individuals/m^2) was found in autumn, whereas at Sandspit, the maximum density (1.7 individuals/m^2) was recorded in summer. The minimum density at both sites was observed in winter (Korangi 2 individuals/m^2 and Sandspit 0.46 individuals/m^2).

DISCUSSION

The investigations of this study demonstrate that Littorinidae, Potamididae and Ellobiidae, typical of tropical mangals (Mac Nae, 1968), are all well represented in the study sites. Wells (1990) recorded 24 mollusc species from Hong Kong mangals, accounting for 75% of the total invertebrates. Berry (1972) reported 32 species of gastropods from the mangals of the Selangor coast of west Malaysia. George (1995) collected 51 species of gastropods from nine Hong Kong mangals, with a median of 25 species for all the sites. Sasekumar (1974) also reported 25 species from the mangals of Port swettenham, West Malaysia. Tirmizi and Barkati (1983b) reported 30 species of molluscs from the mangroves along the Karachi coast, Pakistan. However, the study reports the occurrence of only 14 molluscan species in the two mangrove areas. The low species diversity may be either attributed to the limitation of the study techniques or selection of only two study sites for the study of molluscan diversity phenomenon and that might subtract the rare species occurring at low densities. Yipp *et al.,* (1995) studied the species composition of mangroves associated molluscs and found that these individuals show both regional and local rarity, being confined to one or two sites and occurring at low densities.

Apart from the study method, low species diversity in the region can also be attributed to observing a limited number of suitable habitats and niches in conjunction with the highest salinity recorded at both sites. Sheppared *et al.,* (1992) have also viewed that lack of ideal habitats and prevailing highest salinity are among the factors that can more possibly minimize the species diversity at a particular mangrove area. Furthermore, Mac Nae (1968) observed that the north-eastern extension of the Indo-west pacific region undergoes a progressive subtraction of mangrove associated molluscs. This might be the case at the Karachi latitude. It is worth pointing out that Tirmizi and Barakati (1983b) have also studied the molluscan fauna along the Karachi coast and reported 30 species of molluscs. They have mentioned that all the species they have reported are also common outside the mangrove environment. The main reason of this local difference in species number is obviously the differences in the study methods, as well as the fact that they have studied more sites and collected all the species including castoff shells within the mangrove vicinity without considering their ecological association with mangrove habitat.

All the species collected are epifaunal in distribution and virtually no

infaunal species (except dead shells and juveniles of Potamidids) were recorded. Gao and Li (1985), Well (1984, 90) and Jiang and Li (1995) have also reported the dominance of epifaunal molluscs over the infaunal molluscs in mangrove environment. The main reason observed for the absence of infaunal molluscs is the impenetrability of the dense root masses in addition with the abundance of solid waste pollutants accumulated in the soft sediments in most of the station studied. Similar observations have also been recorded by Wells (1984). However, Vermeij (1973) attributed the absence of infaunal molluscs to the acidic conditions in the mangrove sediments. Berry (1963), Mac Nae (1967), Brown (1971), Sasekumar (1974), Wells and Slack-smith (1981) and Wells (1984) have also stated that the absence of infaunal molluscs is a consistent feature of mangrove habitat.

The data (Table 1) also revealed that seven gastropods species (mainly pulmonates) are exclusively mangroves associated. Three prosobranchs and two bivalve species could be found in sheltered shores, even in the absence of mangroves. It appears that these mangrove associated molluscs are not dependent on the mangrove plant but they share a common requirement for selected soft shores. Further to that, these molluscs might be using these mangals as an alternate habitat. Morton and Morton (1983) and George (1995) have also proposed a similar conjecture.

Turbo coronatus, Cymia carinifera, Crassostrea gryphoides, and *Crassostrea madrasensis* were collected only from the low tide seaward zone at Korangi mangroves but were most ubiquitous, as they were on the sheltered rocky shore of Korangi sites where they attached themselves to the rocks, boulders and dead wood planks. A similar tendency of acquiring dual habitat in molluscs has also been reported by Chambers (1980), Morton & Morton (1983), Takenouchi (1983), McMahon and Cleland (1990). Likewise, *Clypeomorus bifasciatum* and *Cerithidea cingulatus* were also seen in abundance on the exposed mudflats of Sandspit and Korangi.

Following Ahmad (1980), *Telescopium telescopium* and *Cerithidea cingulatus* were identified as around the year breeders whereas *Onchidium sp.* as a summer or monsoon breeder. The number of species and density (individuals/m^2) vary with reference to the season-- high in summer and autumn, and low in spring and winter. Jiang and Li (1995) have also noticed seasonal variations in mangrove associated molluscan communities. *Onchidium sp., Telescopium telescopium, Cerithidea cingulatus* and *Haminoe exarata* are eurhaylinous and therefore categorized as permanent dwellers of the two study sites. Seasonal variations with respect to the number of species are noticed only for those species that are either purely non-mangrove or inhabit both mangrove and non-mangrove habitats. This seasonal migration of species in or out of the mangrove appears to be responsible for the seasonal fluctuations in the species compositions. The increase in the number of species in summer and autumn might be the result of the species inward movement for breeding purposes, as mangrove habitats have been established as an ideal zone for breeding and juvenile development (Austin, 1971, Lindall *et al.,* 1973, Phatia, 1976, Krishnamurthy & Prince Jeyaseelan, 1981, Robertson & Duke, 1981). This conjecture is further supported by the fact that most of the Pakistani molluscs (mid-tide) breed in summer and the monsoon period (Ahmad, 1980). The next

possible reason might be the seasonal migration to avoid unfavorable environmental conditions. Cheng *et al.*, (1993) documented that sediment nutrients on the open shore exhaust during summer, due to the high heat, and recharge in the late fall, along with low temperatures and the animal requiring inward migration to seek more food resources.

The overall density values at both sites are also recorded high during summer and autumn. However, the seasonal abundance varies significantly for each species. The highest density of *Cerithidea cingulatus*, 377 individuals/m^2, is recorded at Sandspit in the month of December. The highest average density 3.6 individuals/m^2 for *Telescopium telescopium* was observed at Sandspit in June, whereas, *Onchidium sp*. was abundant (66.4individuals/m^2) at Korangi during September. The highest average density values recorded for the three dominant species of the study area are comparable to the data published for other mangrove areas. At a west African mangal in Ivory coast, *Pachymelania aurita* was recorded at a density of 712/m^2 (Binder, 1968) and *P. fusca* at 1024/m^2 in Cameroon (Plaziat, 1974), while *Cerithidea cingulatus* reached a density of 579/m^2 on the Red Sea coast of Saudia Arabia (Price *et al.*, 1987), and *Onchidium damelii* 1.6/m^2 was recorded by Kenny and Smith (1987) in Cockle Bay Australia.

CONCLUSION

It is concluded from the study that the Karachi mangroves have a comparatively less diversified molluscan fauna as compared to other tropical or subtropical areas. The low species diversity can be attributed either to the study techniques, the small number of study sites or possibly to the geographical locations of the study sites. However, the recorded species are the best representatives of molluscan assemblages of similar areas and need further investigations.

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