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Mud crab (*Scylla serrata*) population in relation to hydrographical parameters in Coringa mangroves, Andhra Pradesh, India.

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Abstract: *The study of habitat ecology of the Coringa mangroves (Andhra Pradesh, India) at three different stations i.e., Kakinada Bay, Coringa and Gaderu regions in relation to mud crab (Scylla serrata) population for a period of two years was presented in this paper. The hydrographical parameters such as transparency, turbidity, temperature, salinity, dissolved oxygen and pH and sand, silt, clay and organic matter of sediment have been studied and correlated with the density distribution of mud crabs at these three stations. To understand the significance of variance among the hydrographical parameters and among the three stations, multivariate analysis like ANOVA was applied. Water transparency, salinity showed significant variation whereas temperature, dissolved oxygen and pH were insignificant among the seasons and months. The density of crabs also showed increase with increasing clay percentage of sediment. The average availability of crabs per 5m² transect in Kakinada Bay was 1.75 crabs/ 5m² whereas at Coringa, it was 2.77 and 2.67 at Gaderu. S. serrata showed a low density pattern at Kakinada Bay where the sand percentage was very high compared to other two stations. Contrary to this, Coringa creek and Gaderu creek were muddy with low sand percentage comparatively high showed more crab distribution confirming the important role played by mud in the distribution of mud crabs. In the sediment characteristics all the observed constituents showed high degree of variance among the stations and a highly significant variation was noticed among the stations in the mud crab density.*

Key words: *Mud crab, Scylla serrata, habitat ecology, hydrographical parameters, population*

Introduction

Mangroves are tropical and subtropical forests found in the intertidal zone along coastlines, and are often located near estuaries and deltas (Spalding *et al.,* 1997). The mangrove ecosystems are of great ecological and economic significance in coastal protection, enrichment of water quality and in production of fishery resources (Kathiresan and Bingham, 2001; Kathiresan, 2003). The organic matter produced in these waters is several times more than the open sea or shelf waters. The innumerable creeks and salt marshes in estuaries are excellent nursery and feeding grounds for a variety of commercially important fish and shell fish. The crabs depend directly on mangrove areas for survival and for feeding on leaves and litter. They play a significant role in the formation of detritus, nutrient recycling and dynamics of the ecosystem. The digging behaviour by crabs enhances aeration and facilitates drainage in the mangrove soils. They are adapted to the sediment conditions, tidal fluctuations and varying salinities found in the mangroves. They are characteristic members of the invertebrate mangrove fauna and have received much attention due to their economic value. One such fertile ecosystem on the east coast of India is the Godavari estuarine system, consisting of Kakinada Bay and the surrounding mangrove vegetation, which harbours about 56% of the total mud crab population. In the mangrove areas, tides exert a major influence on the transport of dissolved and particulate materials within the estuarine boundaries. The physico-chemical feature in such a dynamic system is subject to the effect of ebb and flow twice a day. In turn the biota in the ecosystem is dependent on the habitat ecology of the area. In view of increasing degradation of various water bodies, it is very important to know the water quality and its influence on the distribution of any population in the ecosystem.

The mud crab *S. serrata* inhabits sea grass and algal beds in the mangroves of Pichavaram south India (Chadrasekaran and Natarajan, 1994). Mud crabs are mostly found in estuarine and sheltered coastal habitats and large populations are associated with established mangroves, especially estuaries (Le vay, 2001). But the distribution and abundance of the mud crabs are related to the hydrographical and sediment parameters. Several studies have been made on the hydrographical parameters of the mangrove. But studies on the distribution pattern of the mud crab *S. serrata* in mangroves are scanty. Hence the present study is concentrated on the distribution of mud crab *S. serrata* in relation to the habitat ecology in Coringa mangroves.

Material and methods

The present study was carried out at three different field stations on mud crab population in relation to the hydrographical parameters and sediments for two consecutive years *viz.,* 2007 and 2008. Kakinada Bay region nearer to the Matlapalem creek (16⁰54'20.59''N, 82⁰15' 01.52''E,) where there is relatively minimal mixing of sea water and freshwater. Coringa creek (16°52' 31.88''N, 82° 16' 11.71''E) is located on either side where dense mangrove vegetation with muddy bottom and Gaderu creek (16°51' 07.02'' E, 82°18' 43.51''N) is situated on either side which meets the bay on one side and Gowthami-Godavari on the other side at Bhairavapalem. Monthly samples of water and sediment from three different study stations were collected. The water was assayed for parameters like temperature, transparency, pH, salinity, dissolved oxygen (APHA, 1985) and the sediment for sand, silt and clay using the pipette method (Carver, 1971). Organic matter of the sediment has been assayed by Walkley and Black (1934). The mud crab population at three stations were collected by quadrants of 5 m^2 area in linear transects with the help of hooks to study the density distribution.

Results

Monthly and quarterly distribution of mud crabs in relation to habitat ecology particularly transparency, temperature, salinity, dissolved oxygen and pH of the water and organic matter, sand, silt and clay of the sediment was studied for a period of two years and the mean values are presented.

Hydrographical parameters

Transparency of the waters at Kakinada bay ranged from a minimum of 41.5cm (September) to a maximum of 81cm (May). At Coringa creek it varied from a minimum of 15 cm (August) to a maximum of 36.5cm (February). In Gaderu creek, it was from a minimum of 18cm in July to the maximum of 63.5cm in May (Fig.1). The water temperature at Kainada Bay varied from a minimum of 25. 1^0 C ±0.2 (December) to maximum of 32.7 ^{0}C ± 0.1 (May). At Coringa creek it varied in between 28^0C (August & September) and 32.7^0C (May). At gaderu Creek, minimum temperature was 20^0C ± 0.1 (February) and a maximum was 35.5^0C ± 0.1 (May) (Fig.2). The water salinity at Kakinada Bay ranged from a minimum of 20ppt ± 0.2 (August & December) to a maximum of 32.5ppt ± 0.5 (June & July), whereas at Coringa the minimum and maximum levels were, 0ppt (August) and 19.5 ppt (May). In Gaderu, the minimum and maximum levels were 7ppt (August) and 32ppt (May) (Fig.3). The dissolved oxygen levels at Kakinada Bay, ranged from a minimum of 4 ± 0.01 ppm in September to a maximum of 6.9 ± 0.02 ppm in December and at Coringa the values ranged from 4.3 ± 0.01 ppm (February) to 6.1 ± 0.01 ppm (November). At Gaderu the minimum level of D.O. was between 4.1± 0.01ppm (September) and 7.6 ± 0.05 ppm (November) (Fig.4). The water pH level at Kakinada Bay, ranged from a minimum of 7.1 (July) to a maximum of 7.65 (November). At Gaderu the pH ranged from a minimum of 6.95(July) to a maximum of 7.7 (June) (Fig.5).

Sediment analysis

Organic matter of the sediment at Kakinada Bay, high content (2.65%) of organic matter was found in May and June and low value (1.35%) in January, whereas in Coringa creek it ranged between 2.6 % (January) and 1.45% (September). At Gaderu it ranged between a minimum of 1.9% (October) to a maximum of 2.5% (February) (Fig.6). The high percentage of sand was observed in September (48.5%) and low November (4.5%) at Kakinada bay. At Coringa the low and high level of sand in the sediments was observed in October with 5% and in June and July with 17% respectively. At Gaderu high sand content in sediment was observed in June (15.5%) and low (6%) in November (Fig.7). Silt percentage varied from a minimum of 42.5% in January, September and December to a maximum of 47% in November at Kakinada. In Coringa it was from a minimum of 31% in December to a maximum of 46.5% in June. At Gaderu, high (57%) and low (33%) levels of slit observed in May and December (Fig. 8). Clay percentage, varied from a minimum of 8% in the month of May to a maximum of 48.5% in the month of November. At Gaderu, it was from a minimum of 30% in May to a maximum of 59% in the month of December (Fig. 9).

Density distribution of mud crab population

At Kakinada bay, crabs were available in all the months, more number in November and December. At Coringa the density of crabs ranged from minimum of one in April, May, June, July and August and maximum number observed was 5 in December. In Gaderu, the availability of crabs ranged from a minimum of 1 in March & May and a maximum number of 4 in September and December 2007 (Fig.10).

ANOVA was extended to the data of hydrographical and sediment characteristics to understand the significance of variance. Among the three stations transparency and salinity have showed highly significant variation and the temperature, dissolved oxygen and pH were insignificant. In the sediment characteristics all the observed constituents showed high degree of variance among the stations and a highly significant variation was noticed among the stations in the mud crab density.

Discussion

Mangrove habitat is a complex and diverse ecosystem which is highly productive because of varying physico-chemical parameters prevailing in this area. Mud crabs in mangrove habitats show distinct distributional patterns relating to water and substrate characteristics like salinity, temperature, dissolved oxygen, the degree of tidal inundation etc. According to Kangas (2000) temperature and salinity play an important role in the distribution, activity and movement of blue swimmer crab. However, conditions determining local distribution and abundance of the mud crab species are complex (Le Vey, 2001). As the crabs live in burrows, aeration draining of soils nutrient exchange will take place between the sediment and overlying waters (Ruwa, 1997). Further the sediment acts as a reservoir of nutrients in aquatic ecosystem, replenishing these nutrients in times of need and their consequent removal helps in the biological cycle of the system. Generally mud crabs live in the inter- and sub- tidal habitats where they feed predominantly on molluscs and other invertebrates (Hill, 1980). The physico-chemical and sediment characteristics will influence the availability of food organisms of crabs and indirectly affect the distribution of mud crabs.

Environmental characteristics are correlated with the density distribution of mud crabs at the three stations. Annual flooding of the rivers during monsoon period is the characteristic feature of many tropical estuaries. Area of the mangrove region experiences extreme variation in physico-chemical parameters reflecting on the distribution pattern of mud crabs at the three different study stations of Coringa mangroves. Kakinada Bay, the Coringa and the Gaderu canals are influenced by sea water on one side during high tides and freshwater influx from the landside during monsoon months. They are also influenced by the sewage, agricultural discharges, industrial wastes etc. The water parameters like transparency, temperature, salinity, pH, D.O. etc. and the sediment characteristics like sand, silt, clay and organic matter are influenced on either side by seawater and freshwater which in turn reflect on the distribution of organisms. In the present study, the hydrographical parameters exhibited greater fluctuations both in time and space with a marked variation from station to station.

Water transparency is an important physical property of the estuarine waters as it directly and indirectly influences the productivity through the constituents of water like dissolved oxygen, carbon dioxide and nutrients. Suspended sediments of water have a negative correlation with the transparency. Panigrahi (2005) has reported a negative correlation in Chilka waters. Analogous observations have also been made by several researchers in the coastal system of India (Nair *et al.,* 1983; Sai Sastry and Chandramohan, 1990;

Chandran and Ramamoorthi, 1984; Qasim, 1980; Qasim and Sengupta, 1981). Rao and Murthy, (2010) has observed 24.3 cm, 14.3cm and 19.3cm of transparency in premonsoon, monsoon and post monsoon months respectively in the Vashista and Vainateyam estuary. Transparency ranging from 0.61m to 0.74m in winter and 0.33m to 0.59m in summer has been observed by Panigraghi (2005) in Chilika lake.

Marked variation of transparency is seasonally noticed at all three stations. It has been observed that the transparency is low in the third quarter at Kakinada bay and Coringa stations except at Gaderu. In all three stations the transparency is very high in summer. This could be attributed to the low influx of freshwater during pre monsoon months *i.e.* in the second quarter of the study period. The low transparency has been observed in the third quarter due to the maximum annual flooding of freshwater during monsoons. This is in correlation with the observation of Dehadri (1970), Dwivedi *et al* (1974), Sai Sastry and Chandra Mohan (1990). Mishra (1973) has reported high sediment concentration and low transparency in the months of August and October *i.e.* in monsoon period and highest transparency has observed in pre monsoon in the coastal waters of Orissa coinciding with the present observations. High transparency is noticed at Kakinada Bay. High transparency has been found in summer at all stations. The high transparency may be due to the lower productivity in Kakinada bay where the mangrove vegetation is less and also low influx of inland waters along with leached sediment. Further, the low clay content and organic matter in the sediments leads to low plankton turbidity to the waters. The lower transparency at Coringa and Gaderu are mainly due to the shallowness of waters and high clay content of suspended bottom sediment in the waters. Transparency has also been influenced by the tidal fluctuations in the Bay and also in the narrow creeks.

Temperature of water is more influenced by the atmospheric conditions and conduction from the bottom in the shallow regions of the creeks. It affects a number of physical, chemical and biological processes in natural aquatic ecosystems. Within the mangrove habitat, the stagnated waters are subjected to evaporation and record higher temperatures. Temperature is an important factor in the environment which influences the other conditions of ecosystem (Valliela, 1995). It has been governed by exchange of waters between estuary with the adjacent seas and also atmospheric temperature variation (Borego and Borego, 1982). The water temperature at three stations of the study area has showed a marked seasonal variation as observed in the previous studies. Qasim *et al* (1969) have reported that the Vellar estuarine waters are more influenced by atmospheric temperature than the tidal variations. The phenomenon of high and low temperature of waters coinciding with the pre monsoon and post monsoon seasons has been reported at Pulicat lake by Raman *et al* (1975), in Vellar estuary (Chandran and Ramamoorthi, 1984), at of Chilika Lake by Panigrahi (1985).

Hill (1975) has reported 20^{0}C to 28^{0}C in summer months and 12^{0}C to 16^{0}C in winters in Kowie and Kleinemond estuaries on the east coast of South Africa. Prasad (2002) has observed 29.0 to 29.5^{0}C at Kakinada bay region, 30.2^{0}C at Coringa and 28.9^{0}C at Gaderu. Panigrahi (2005) has found 23.73^{0}Cto 26.41^{0}C mean temperature during winter and 30.24^{0}C to 32.53^{0}C during summer months in Chilka waters. Mishra (1979) has observed 23^{0}C to 28^{0}C of surface temperature in the coastal waters of Orissa. According to him the water temperature remained high during summer months, low during winter period and moderate in other seasons. Kumari and Rao (2009) has noticed the decrease in temperature (30.0 ± 0.09^{0}C) from May to September (29.2 ±0.08^{0}C) and to February (26.6±0.06^{0}C) in Krishna estuary. Rao and Murthy (2010) have reported the temperatures of 24.2^{0}C, 23.8^{0}C and 21.33^{0}C in the Vasistha and Vainateyam estuary which is a part of Godavari estuary.

In the present study it is observed that the water temperature recorded is high during the summer months at three stations and low in winter months at Kakinada bay and Gaderu and in the winter at Coringa owing to the influence of seasonal atmospheric temperature. Among the three stations maximum temperature is recorded at Gaderu station with 35.5^{0}C (May). The depth of the station may be the reason for the high temperature. Gaderu creek shows an average depth of 2m, which is less than the other stations. Within the mangrove habitat, the waters are subjected to evaporation in the stagnated water where higher temperatures are recorded. Kumari and Rao (2009) have attributed that the presence of anthropogenic and agrochemical constituents and the influence of ionic strength from the head to mouth may result in the increase of heat retention capacity of the Krishna estuarine waters. This may be the reason for the high temperature observed in Gaderu region where there is an increased anthropogenic and industrial influence. In the Bay region, the temperature fluctuations can be attributed to the mixing process as the water of the open Bay region enters the creeks during high tide and recedes during the low tide, the water from the shallow creeks with relatively higher temperature returns to the Bay.

The distribution of salinity is under the influence of physical factors like the fresh water discharge, tides and the prevailing circulation pattern existing in the area. The flood tides bring about higher saline water into the mangrove region where moderate mixing of different water masses takes place. Thus salinity fluctuations are high in the mangrove dominant regions. According to Nair (1974) a steep gradient in salinity during the post monsoon period (November) with a minimum values (28.6ppt) at the bar mouth and very low (0.2ppt) towards the head of the estuary in Cochin backwaters. He states that higher salinity has been reported throughout the length of the estuary with a range of 25.3 - 33.5ppt during the pre monsoon period (April). Varma *et al* (1975) have reported a maximum horizontal gradient in salinity during monsoon (2.35ppt/km) and minimum (19ppt/km) during pre-monsoon and at intermediate levels during post-monsoon. Ramanadham and Varadarajulu (1975) have reported higher values of salinity in the range of 35.5 to 35.9 ppt in the upstream in May and 35 ppt at the mouth of the Krishna estuary. Chandra Mohan (1977) has observed wide fluctuation in salinity varying from 1.38ppt to 33.43ppt in Godavari estuary. Srikrishna Das and Ramamoorthi (1982) have reported the salinity variation of 26.2 ppt to 34.8ppt in Porto Novo waters of Vellar estuary. Divakaran *et al* (1980) have recorded a salinity range of 27.9ppt to 36.2 ppt in the inshore waters of Vizhingam.

Nair *et al* (1983) have reported the patterns of distribution of salinity *i.e.* high saline periods during pre monsoon period (February to May), low saline period of monsoon period (June-November) and a period of recovery during post northeast monsoon period (December–January) in Cochin backwater. Bhat and Gupta (1983) have observed reduction in salinity towards the upstream stretches during the post and early pre monsoon periods in Netravathi–Gurupur estuary of Mangalore. According to Goswami (1983) the mean salinity ranges from 16.24 ppt to 27.95ppt in the surface waters of Mandovi-Zuary estuary of Goa. Tripathy *et al* (2005) have reported higher salinity (31.4 psu) at Kakinada bay region which is nearer to the open coastal waters and low salinity (0.27 psu) has been noticed in Coringa mangrove environment.

Salinity in the study period varied from normal seawater 32.5ppt in Kakinada bay to almost freshwater conditions in Coringa in August and and 32ppt in Gaderu. Marked variations in salinities observed seasonally. At Kakinada bay water salinity is relatively high in May coinciding with the summer (pre monsoon) season when there has been a complete cessation of freshwater inflow. Following the onset of south-west monsoon period (June - August), there has been a steady decrease in salinity and reached minimum of 20ppt owing to peak freshwater influx from the Coringa and Gaderu canals. During the influx of freshwater at the time of floods, the entire mangrove area bordering Gaderu and Coringa creeks gets inundated and incoming tidal effect from the Bay end is almost negligible. With decreasing freshwater influx, the tidal influence is gradually felt, and shows greater influence in summer months. During the summer dry seasons, the high saline water from the Bay region enters into the mangrove area through Gaderu, Coringa and adjacent creeks. In summer months, water entering into the narrow creeks in the vicinity of mangroves during high tide, may experience evaporation and stagnation, this in turn may lead to hyper saline condition. With the receding tide, these waters find their way and flow down into the Bay through the canals. Rama Sarma (1965) has reported that the river Gaderu and Coringa which are open on both ends, receives different water masses from both the ends, thus the central part of the river experiences piling up and stratification of water masses.

The physical mixing of the fresh and seawater with different oxygen concentrations change the D.O levels in the estuaries (Panigrahi, 2005). Pal and Mohanty (2002) have reported 6.0 to 14.20ml $l^{-1,}$ while Jhingran (1991) has reported 2.6 to 15.6ppm of D.O in Chilika lake. Panigrahi (2005) has observed 7.06 to 8.95ml l^{-1} of D.O in near shore waters, of Chilika lake, while in interior of the lake a wide range of 3.45 to 9.98ml l^{-1} has been recorded. Tripathy *et al* (2005) have observed 5.85 to 8.65 ppm (mean 7.03±0.93) at Kakinada bay region, 5.49 to 6.38 ppm (mean 5.87±0.33) at Gowthami Godavari estuarine region, and 1.39-5.45 ppm (mean 2.88±1.55) at mangrove region of Coringa. In the present study high D.O levels have been observed in winter and in summer at Kakinada bay and Coringa with 6.9 ppm and 6.1 ppm respectively and in November (7.6 ppm) at Gaderu. Panigrahi (2005) has also made similar observations in Chilika Lake wherein high oxygen levels are noticed in winter than in summer. The same observation has been made by Tripathy *et al* (2005) in Coringa region with low DO level of 1.39 mg l^{-1} it may be attributed to the stagnant and non- flushing conditions of the water with increasing waste load in the mangrove environment.

The hydrogen ion concentration in waters is interrelated with other hydrographical parameters of water and sediments and plays a vital role in the distribution of estuarine population and their biological characteristics. Harvey (1960) has reported that the pH of estuarine waters is more variable than the marine and fresh waters. The pH of the estuarine waters depends on the proportional mixing of fresh- and sea-water having different pH values (Panigrahi, 2005). Alkaline waters are noticed in several estuarine waters by several researchers (Banerjee and Roychoudhury, 1966; Pal and Mohanty, 2002) in Chilika waters; Mishra (1979) in the coastal waters of Orissa. High pH has been noticed during pre monsoon (February-May) and low during monsoon period (June-September) by Prasad (2002) in Godavari estuary. The difference in pH value is not significant in Kakinada Bay, Gaderu and Coringa during the study period. This is in correlation with the findings of Prasad (2002) wherein he has observed 6.2 to 7.9 pH range among stations and mean pH values of 7.10, 7.10 and 7.05 in Kakinada bay, Gaderu and Coringa stations respectively. Sara *et al* (2014) have found that the water parameters such as depth, salinity, turbidity measured at three different habitats (A, B & C) fluctuated during seasons.

Sediment acts as the reservoir of nutrient material in any aquatic ecosystem (Manjappa *et al.,* 2003). The replenishment of nutrients in times of need and their consequent removal greatly helps in the biological cycle of the system. Such an exchange of nutrients depends upon the characteristics of sediment and hydrographical features of the estuary. Sunil (2000) has reported that mangrove soil is biologically rich and provides unique ecological niche to a wide variety of soil dwelling organisms. It has been recorded that the nature of sediments (clay to sand) has a great bearing on the faunal distribution of the mangroves (Brij Gopal and Malavika Chauhan, 2006).

In the present study, the percentage of clay differed from station to station. In Kakinada bay, Coring and Gaderu, the average percentage of the clay is 13.08%, 48.14% and 43.75% respectively. The reason for the low percentage of clay in Station I may be due to the fact that the station is far from the mangrove rich area compared to other stations and is almost marine environment. Further the rich organic material which is flooded during the monsoon season from long distances will generally be settled at the mouth of the distributaries mainly at Coringa and Gaderu. This is the reason for the productive rich clayey sediments of Coringa and Gaderu stations. The density of crabs also shows corresponding increase with the clay percentage of sediment. The availability of crabs per $5m^2$ transect in Kakinada is 1.75 crabs/ $5m^2$ where as in Coringa there is increase in the density of crabs 2.17. In Gaderu, it is 2.67 crabs/ $5m^2$. According to Sivasubramanaiam and Angell (1992), the mangrove biotope offers mud crab production is about $2t/km^2$ whereas in the present study area, the mangrove rich station *i.e.,* Coringa produces about 0.5 t/km^2. Hill (1975) has observed the population density in the closed estuary is 1 crab/124m^2 in South Africa.

There is a positive correlation in relation with the clay and density of crabs in the present study. The clay percentage in the sediments of the three stations showed a marked increase from the summer to post monsoon season due to the deposition on organic matter by monsoon floods. Soundarapandian *et al* (2008) have noticed the dominance of *P. sanguinolentus* and *Talamita chaptali* which are free living Brachyuran crabs, in sand dominated substrata in Pichavaram mangrove area. As a mud burrowing crab, *S. serrata* has shown a low density pattern in both years in Kakinada bay where the sand percentage is very high compared to other two stations. Contrary to this, Coringa and Gaderu are muddy substrate areas where the sand percentage is low and clay percentage is high when compared to Kakinada bay have shown a dominance of mud crab *S. serrata* in both stations. By this study it is confirmed that substrate or sediment plays an important role in the distribution of mud crabs.

Soundarapandian *et al* (2008) have observed that the crab population is high during monsoon and post monsoon months in Pichavaram mangroves. According to them factors such as salinity, possible physical changes in the substrate composition and availability of maximum organic carbon during monsoon and post monsoon seasons may be attributed for greater abundance of crabs. The same observation has been made in fourth quarter of the two years study period at three stations. It is found that there is a steady increase in the crab population in all three stations from October to December except in the Kakinada Bay region where there is no availability of crabs during the month of October.

Sand is more in Kakinada bay and offers little scope for the growth of the crab and as a result the density of distribution of crabs from this area is very limited. The Coringa and the Gaderu areas are with relatively high clayey sediments containing more organic matter derived from the mangrove foliage and the flow of rich nutrient material that has been dumped at the mouths of the numerable creeks and the main distributaries at the time of flood season. This gives much good habitat for the crabs to burrow. A sand bottom inhibits the burrowing of the crab holes due to the collapsing nature of the passageway while burrowing. The gradual rise in density of the crab population from Kakinada bay to Coringa and Gaderu is definitely due to the good percentage of clay. This has been supported with the findings of Mohanty *et al* (2006) in Chilika lagoon, Orissa, where the density of *S. serrata* is more than *S. tranquebarica* in muddy and shallow area rather than in sandy area.

The present study revealed the predominance of *S. serrata* population in Coringa and Gaderu of the study area compared to Kakinada bay. Crustacean fauna of these areas as a whole are very rich as they invade mangroves from the adjacent intertidal habitats during the high tides and organic rich detritus mangrove plant material carried in through the fresh water influx during monsoons. The smaller crustaceans, decapoda, molluscs and detritus are the main feed items of *S. serrata* (Ramana Murthy, 1991). Narasimham *et al* (1984) have reported that entire Kakinada estuarine habitat is rich in molluscan fishery. This is also one of the reasons for the abundance of the *S. serrata* in Coringa and Gaderu. A positive correlation is observed with the density distribution of the respective stations of the present study. It shows the preference of the rich organic habitat of mud crabs. Thus the hydrographical and sediment parameters do play a vital role in the distribution pattern of mud crab, *S. serrata.*

Sara *et al* (2014) have found that the relative abundance of *S. serrata* at habitat A (dominated by silt) differed significantly with habitats B (dominated by clay loam) and C (dominated by sandy loam) ($p < 0.05$), while at habitat B was not significantly different with habitat C ($p > 0.05$). It suggests that *S. serrata* tended to move forward at habitat A and occupying such habitat which was characterized by low salinity, high turbidity, the thickest mangrove vegetation, muddy substrate and the widest intertidal flat. The relative abundance of males was significantly different with females either during flood tide or ebb tide ($p < 0.05$). They also found that the seasonal relative abundance was not significantly different ($p > 0.05$). It suggests that the relative abundance may depend on seasons but they are found all year round in Lawele Bay, Indonesia. Riipinen *et al* (2017) have observed that *Rhithropanopeus harrisii* preferred the shelter of the rock habitat, indicating that *R. harrisii* choose their habitat based on habitat structure rather than food availability in the habitat. However, the preference for sheltered rocky bottom habitats also exposes the associated *Fucus vesiculosus* communities to the impacts of *R. harrisii* through predation.

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References

APHA (American Public Health Association) (1985). Standard methods for the examination of water and wastewater, New York.

Banerjee AC, Roychoudhury NC (1966). Observation on some physico-chemical features of the Chilika lake. Indian Journal of Fisheries 13: 395-429.

Borego AS,. Borego SA (1982). Temporal and spatial variability of temperature in two coastal lagoons. Cal. Coti. Rep., XXIII: 185-197.

Brij Gopal, Malavika Chauhan (2006). Biodiversity and its conservation in the Sundarban Mangrove Ecosystem. Overview article. Aquatic Sciences, 13: 1-17.

Carver RE (1971). Sedimentary petrology. John Wiley and Sons Inc, London.

Chandrasekaran VS, Natarajan R (1994). Seasonal abundance and distribution of seeds of mud crab *Scylla serrata* in Pichavaram Mangrove, Southeast India. Journal of Aquaculture in the Tropics 9: 343-350.

Chandran R, Ramamoorthi K (1984). Hydro biological studies in the gradient zone of the Vellar estuary: II. Nutrients. Mahasagar-Bulletin National Institute of Oceanography 17: 133-140.

Chandra Mohan P, Rao RG, Dehairs F (1997). Role of Godavari mangroves (India) in production and survival of prawn larvae. Hydrobiologia 358: 317-320.

Dehadri PV (1970). Changes in the environmental features of Zuari and

Mandovi estuaries in relation to tides. Proceedings of Indian Academy of Sciences 57(2B): 68-80.

Divakaran O, Arunachalam M, Nair NB, Padmanabhan KG (1980). Studies on the zooplankton of Vizhinjam inshore water, south west coast of India. Mahasagar-Bulletin National Institute of Oceanography 13(4): 335-341.

Dwivedi SN, Bhargav RMS, Parlekar AM, Selvakumar RA, Singbal SVS, and Sankaranarayana VN (1974). Ecology and environmental monitoring of Mandovi, Zuari and Camburzua canal complex during monsoon months. Journal of India Fisheries Association 3-4: 113-130.

Goswami SC (1983). Coexistence and succession of copepod species in the Mandovi and Zuari estuaries, Goa. Mahasagar-Bulletin National Institute of Oceanography 16(2): 251-258.

Harvey M (1990). Mud crab culture in Thailand. INFOFISH int. (FA), (6): 53-54.

Hill BJ (1975). Abundance, Breeding and Growth of the Crab *Scylla serrata* in two South African Estuaries. Marine Biology 32: 119-126.

Hill BJ (1980). Effects of temperature on feeding and activity in the crab *Scylla serrata*. Marine Biology 59: 189-192.

Jhingran VG (1991). Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi. 727pp.

Kangas MI (2000). Synopsis of the biology and exploitation of the blue swimmer crab, *Portunus pelagicus* Linnaeus, in Western Australia. Fisheries Research Report 121.

Kathiresan K (2003). Ecology and environment of mangrove systems. UNU-UNESCO International Training on Biodiversity in Mangrove Ecosystems: 63-73.

Kathiresan K, Bingham B L (2001). Biology of mangrove and mangrove ecosystems. Advances in Marine Biology 40: 81-251.

Kumari RV, Rao IM (2009). Estuarine characteristics of lower Krishna River. Indian Journal of Marine Sciences 38(2): 215-223.

Le Vay L (2001). Ecology and management of mud crab *Scylla* spp. Asian Fisheries Science 14(2): 101-112.

Manjappa H, Gowda G, Rajesh KM, Mrudula RM (2003). Sediment characteristics of mangrove areas of brackish water impoundments. Indian Journal of Fisheries 50(3): 349- 354.

Misra PM (1979). Fisheries of Orissa. Symposium on Recent Trends in Antropological Studies 4: 10-13.

Mohanty SK, Mohapatra A, Rajeeb K, Mohanty KS, Bhatta, Pattnaik AK (2006).

Occurrence and biological outlines of two species of *Scylla* (De Haan) in Chilka lagoon, India. Indian Journal of Fisheries 53(2): 191-202.

Nair VR (1974). Distribution of chaetognaths along the salinity gradient in the Cochin backwater, an estuary connected to the Arabian Sea. Journal of Marine Biological Association of India 16(3): 721-730.

Nair NB, Abdul Azia PK, Dharmaraj K, Arunachalam H, Krishan Kumar K, Balasubramanian NK (1983). Ecology of Indian estuaries. Part I-Physico-chemical features of waters and sediment nutrient of Asthamudi estuary. Indian Journal of Marine. Science 12: 143-150.

Narasimham KA, Selvaraj GSD, Lalitha Devi S (1984). The Molluscan resources and ecology of Kakinada Bay. Marine Fisheries Information Service Technical Bulletin Series 59: 1-16.

Pal SR, Mohanty PK (2002). Use of IRS-1B data for change detection in water quality and vegetation of Chilka lagoon, east coast of India. International Journal of Remote Sensing 23: 1027-1042.

Panigrahi RC (1985). Phytoplankton and primary productivity in Chilka Lake. *Ph.D.* Thesis submitted to Berhampur University, Berhampur, India.

Panigrahi S (2005). Seasonal variability of phytoplankton productivity and related physico- chemical parameters in the Chilka Lake and its adjoining sea. Ph. D. Thesis submitted to Berhampur University, Berhampur, India

Prasad NV (2002). Characteristics and its production in the Bay-Estuarine water ways of Coringa mangroves, South east coast of India. Ph.D. Thesis, Andhra University.

Qasim SZ (1980). Adaptation in phytoplankton to changing conditions in tropical estuaries, Mahasagar- Bulletin, National Institute of Oceanography 13: 117-124.

Qasim SZ, Sen Gupta R (1981). Environmental characteristics of the Mandovi- Zuari estuarine system in Goa. Estuarine Coastal Shelf Science 13: 447-578.

Qasim SZ, Wellershaus S, Battathiri PMA, Abidi SAH (1969). Organic production in a tropical estuary. Proceedings of Indian Academy of Sciences 69:51-74.

Raman K, Ramakrishna KV, Radhakrishnan S, Rao GRM (1975). Studies on the hydrobiology and benthic ecology of Lake Pulicat. Bulletin Department of Marine Science VII: 855-884.

Ramanadham R, Varadarajulu R (1975). Hydrology and hydrography of the Krishna estuary. In: Recent Researches in Estuarine Biology. (Ed. Natarajan. R.).Hindustan Publ. Co. (I), Delhi. Pp: 151-164.

Ramanamuthy KV (1991). Management of Mangrove Ecosystem of Andhra Pradesh (Godavari and Krishna Estuary) in relation to Development of Fisheries and Brackish water culture. Report to Dept of Fisheries. Andhra Pradesh, India. pp: 88.

Ramasarma DV (1965). Hydrography of the Godavari estuary. Ph. D. Thesis, Andhra University, Waltair.

Rao GMN, Murthy PR (2010). Mangrove and Associated Flora of Vashista and Vainateyam Estuaries, A.P. India. Notulae Scientia Biologicae 2(4), 40-43.

Riipinen K, Mikkola S, Ahola MK, Aalto MM, Alisa O, Vesakoski O (2017). Habitat selection of the mud crab *Rhithropanopeus harrisii* in its newly invaded range. Aquatic Invasions 12 (2): 191–200.

Ruwa RK (1997). Zonation of crabs that burrow or bury in mangrove vegetation soils on the east coast of Kenya. *In* "Mangrove Ecosystem Studies in Latin America and Africa" (B. Kjerfve, L.D. Lacerda and S. Diop, Eds) : 316-324. UNESCO, Paris.

Sai Sastry AGR, Chandramohan P (1990). Physicochemical characteristics of Vasistha Godavari estuary, East Coast of India: Pre Pollution status. Indian Journal of Marine Science 19: 42-46.

Sara L, Aguilar RO, Ingles JA, Laureta LV (2014). Habitat characteristics and relative abundance of the mud crab *Scylla serrata* (Forskål, 1775) in Lawele Bay, Southeast Sulawesi, Indonesia. European Journal of Fish and Aquatic Sciences 31(1): 11-18.

Sivasubramaniam K, Anjell C (1992). A review of the culture, Marketing and resources of the mud crab (*Scylla serrata*) in the Bay of Bengal region. In The mud crab, report on the seminar convened in Surat Thani, Thailand, November 5-8, 1991. Ed. Angell, C.A., Bay of Bengal Programme, Madras, India, 5-12.

Soundarapandian P, John Samuel N, Ravichandran S, Kannupandi T (2008). Biodiversity of crabs in pichavaram mangrove environment, South East Coast of India. International Journal of Zoological Research 4: 113-118.

Spalding MD, Blasco F, Field CD (1997). World Mangrove Atlas, Okinawa. International Society of Mangrove Ecosystem : 178-180.

Sri Krishna Das B, Ramamoorthi K (1982). Ecology of polychaete larvae of Port Novo waters. Indian Journal of Marine Science 11: 296-302.

Sunil kumar R (2000). A review of biodiversity studies of soil dwelling organisms in Indian mangroves. Zoos'Print Journal 15(3): 221-227.

Tripathy SC, Ray AK, Patra S, Sarma VV (2005). Water quality assessment of Gautami-Godavari mangrove estuarine ecosystem of Andhra Pradesh, India during September 2001. Journal of Earth System Sciences 114(2): 185-190.

Valiela I (1995). Marine Ecological Processes. Spinger-verlag.

Varma KK, Gangadhara Rao G, Cherain T (1975). Temporal and spatial variations in hydrographic conditions of Mandovi estuary. Indian Journal of Marine Science 4:11-17.

Walkley A, Black IA (1934). An examination of Degtzareff method for determinging soil organic matter and a proposed modification of the Chromic acid titration method. Soil Science 37: 29-37.

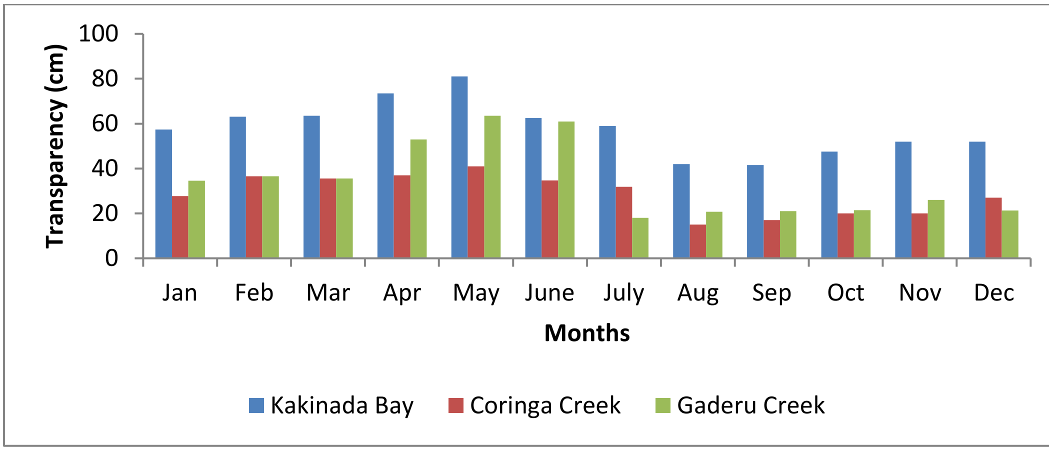

Fig. 1 Transparency of the water at three stations in Coringa mangroves

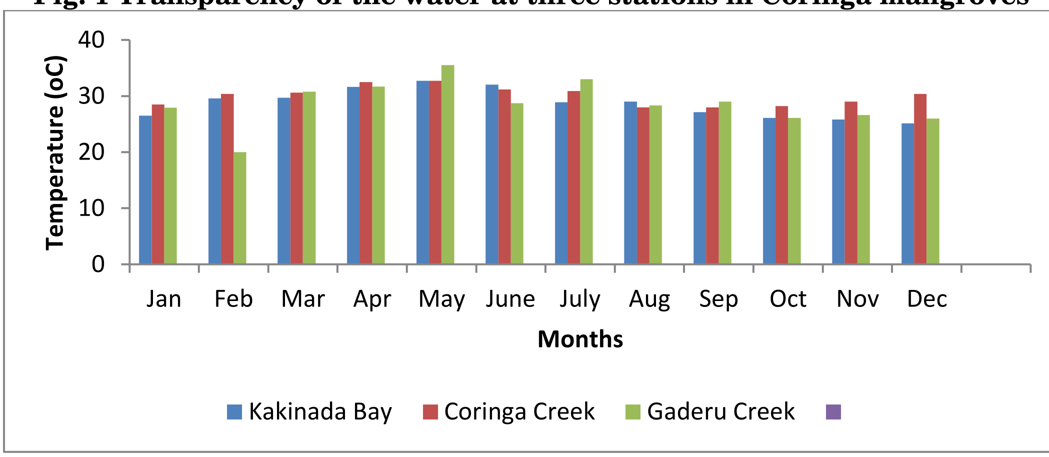

Fig. 2 Temperature of the water at three stations in Coringa mangroves

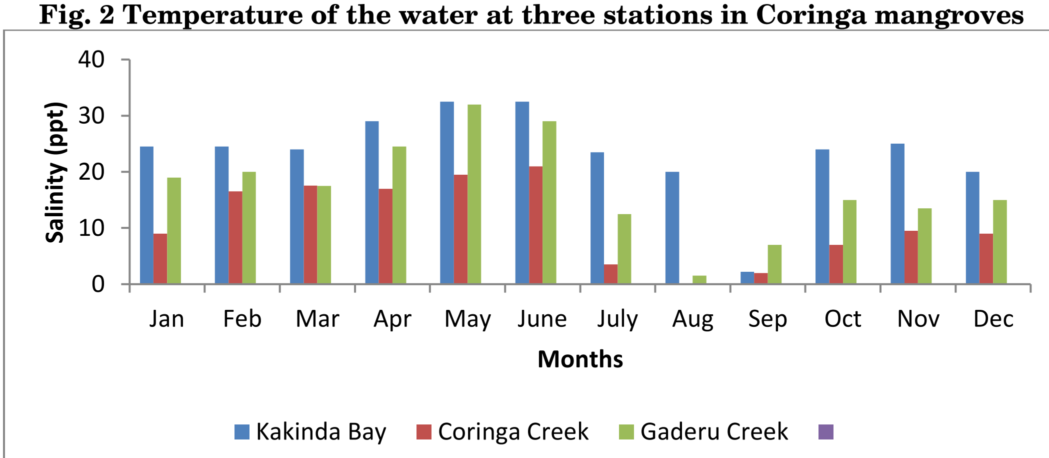

Fig. 3 Salinity of the water at three stations in Coringa mangroves

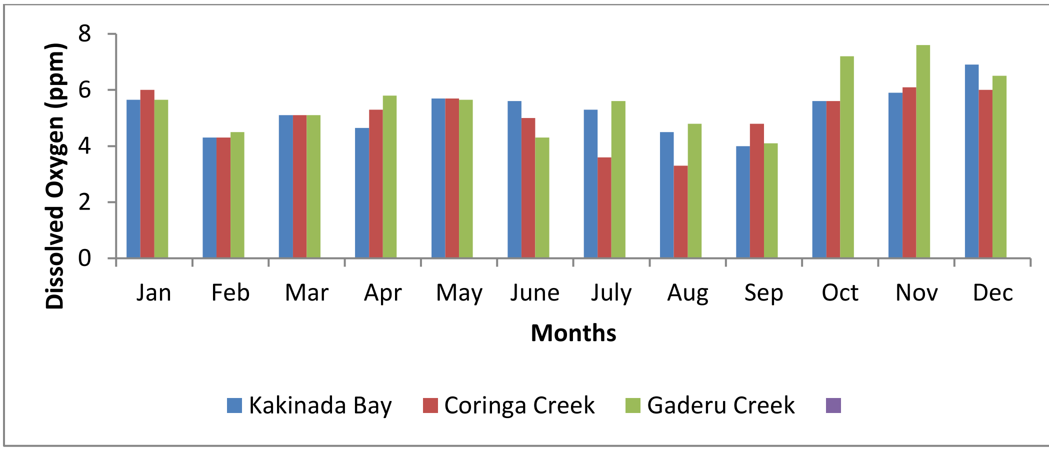

Fig. 4 Dissolved Oxygen of the water at three stations in Coringa mangroves

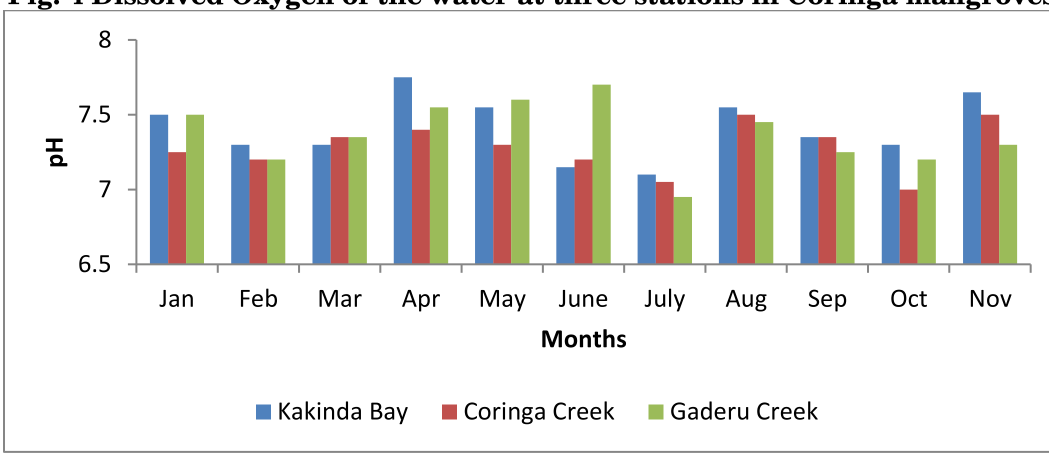

Fig. 5 pH of the water at three stations in Coringa mangroves

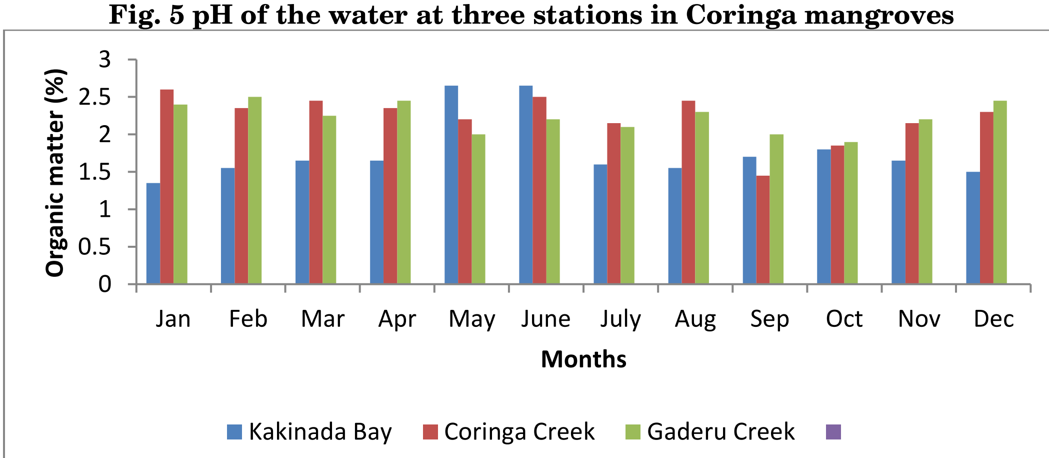

Fig. 6 Organic matter (%) of the sediment at three stations in Coringa mangrove

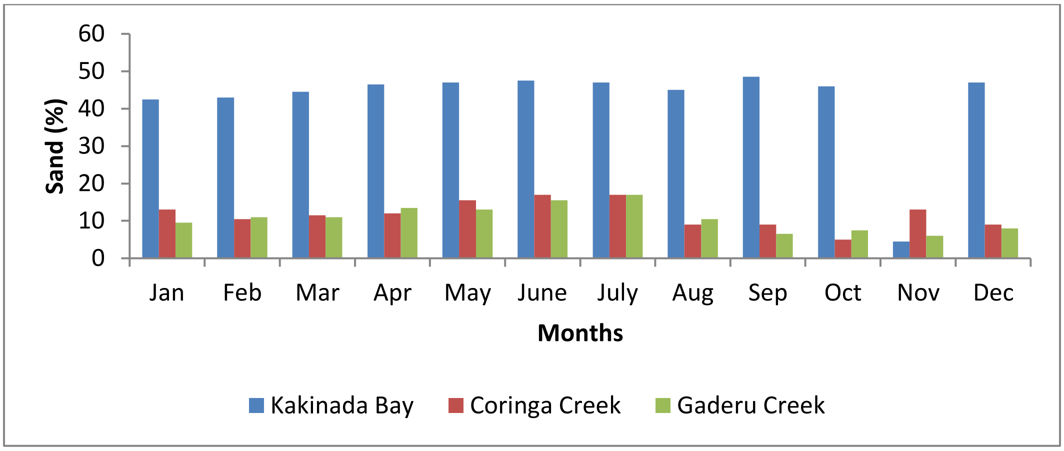

Fig. 7 Sand (%) of the sediment at three stations in Coringa mangroves

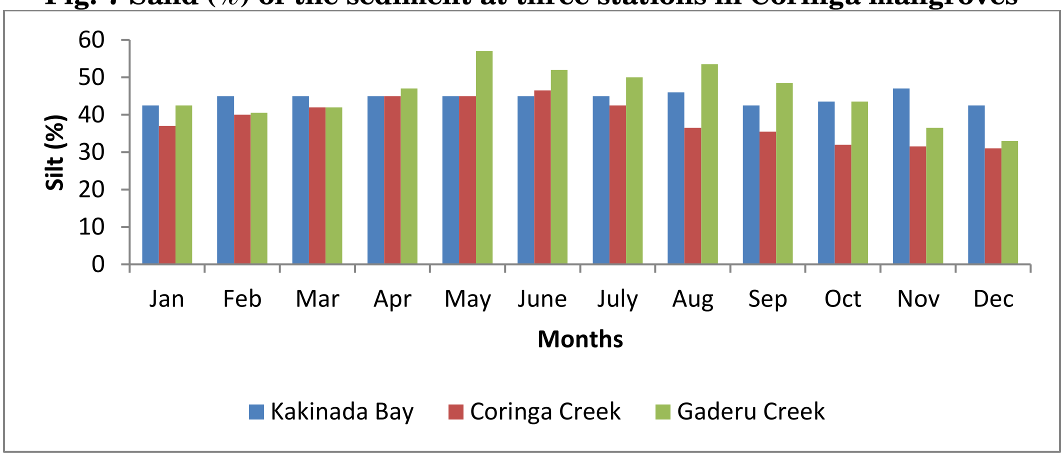

Fig. 8 Silt (%) of the sediment at three stations in Coringa mangroves

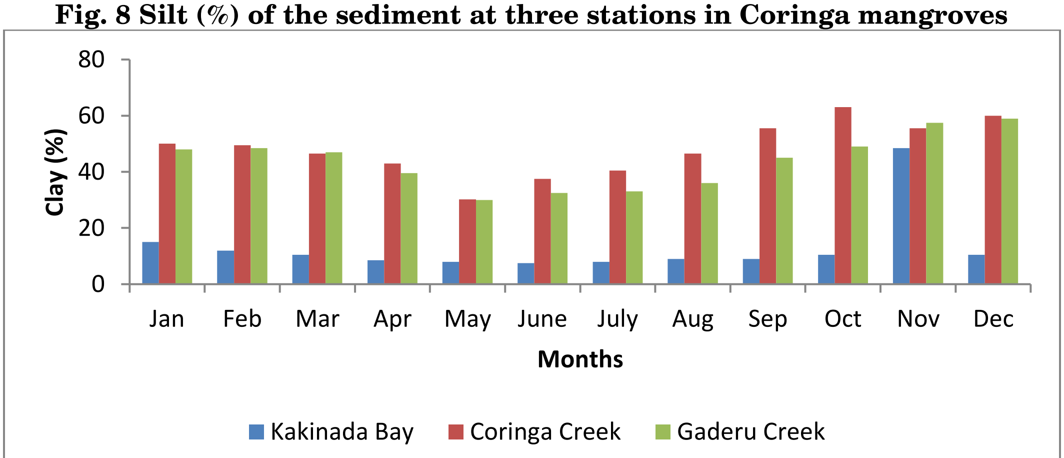

Fig. 9 Clay (%) of the sediment at three stations in Coringa mangroves

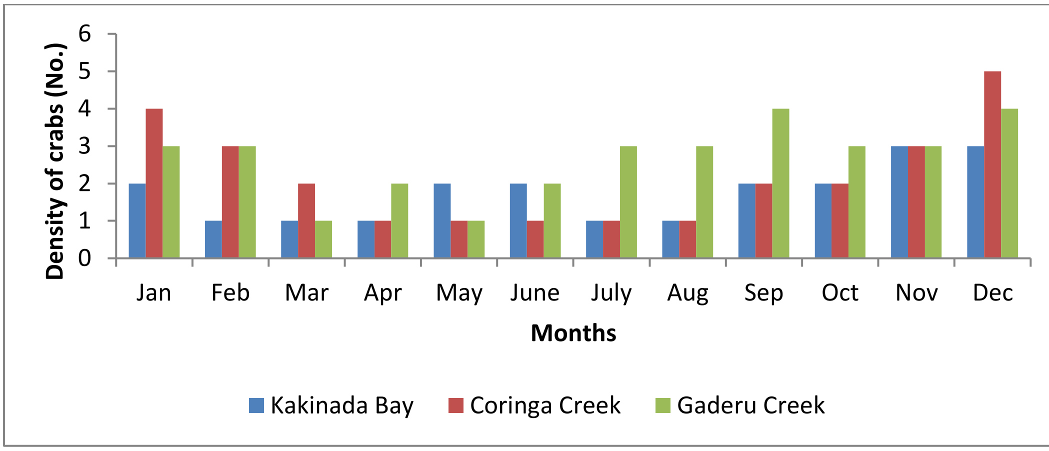

Fig. 10 Density of the crabs at three stations in Coringa mangroves