Chapter 2

REVIEW OF LITERATURE

The relevant literatures pertaining to the present study were collected from the periodicals, Journals, text books, e-journals etc and were incorporated in this chapter. Literatures for hydrographic parameters, sedimentological factors, mangrove ecosystem and biotic faunal communities such as mangroves, zooplankton, macrobenthos, mollusks, arthropods, fin fishes, woodborers and avifauna were collected and are cited in the respective chapters. In this chapter, brief mentions of these references are made at appropriate context.

Chapter 3

MATERIALS AND METHODS

Different methods were followed by adopting the standard procedures in the field as well as in the laboratory to carry out the present study. Manuals of National and International Laboratories were also referred and made use to carry out the experiments.

Chapter 4

HYDROGRAPHIC CONDITIONS OF STUDY SITES

This chapter gives information on environmental conditions (hydrographic parameters) of the study stations for the period of thirteen months from January 2008 to January 2009. To know the environmental conditions of each study stations, some of the hydrographic parameters like water temperature, salinity, dissolved oxygen, hydrogen ion concentration, suspended matter, and nutrients namely phosphate-phosphorus, nitrate-nitrogen, nitrite-nitrogen and silicate-silicon were studied in detail. The correlation coefficient as a measure of mutual relationship between two hydrographic parameters was calculated and discussed.
Chapter 5

SEDIMENTOLOGICAL CONDITIONS OF THE MANGROVE ECOSYSTEM

Sedimentological parameters, such as sediment temperature, sediment pH, sediment moisture, interstitial water, organic carbon and sediment texture (sand, silt & clay), were studied for each study stations and also discussed their variation with space & time scale.

Chapter 6

BIOTIC COMMUNITY IN MANGROVE ECOSYSTEM

Mangrove ecosystem is one of the highly fertile zones of estuarine complex, which is considered as cradle for most of the commercially important fin & shell fish resources. The sediment texture and water quality of this ecosystem favours and create an ideal environment for the biotic communities whether it is aquatic, terrestrial or aerial environments. It is a house for most of the floral and faunal communities. Keeping the importance of this fragile and productive area in view, the present work was undertaken to study the abundance and distribution of faunal community with space and time. The following faunal communities residing in aquatic, terrestrial and aerial environments were studied.

6.1 Distribution of Mangroves

River Kali has variety of habitats such as freshwater, estuary, backwaters, salt marshes, mud flats etc. Among these habitats, the Mangrove ecosystem has been selected for the present study. The lush and evergreen Mangrove floral stretch can be seen in this estuarine complex but in some pockets, they are grown luxuriantly comprising varied groups and species. To study the faunal abundance in such areas of mangroves with thick, luxuriant growth, some areas have been selected such as Mavinahole creek, Kanasgiri, Sunkeri and Kadamawad backwaters and in Kinnar area to carry out the research at length. Totally seventeen mangrove species have been recorded from these five study stations (as mentioned above), and the ecological studies have been carried out in these areas for the period of thirteen months from January 2008 to January 2009.
6.2 Distribution and abundance of Zooplankton in Mangrove ecosystem

In this chapter, the month and season wise variation in the zooplankton density has been portrayed with respect to the study sites located in the mangrove ecosystem of Kali estuary, Karwar. Totally twelve groups of zooplankton (protozoa, coelenterate, ctenophore, chaetognatha, copepod, ostracoda, cladocera, decapoda, polychaeta, pteropoda, protochordata and larval forms) have been recorded comprising fifty two species, the quantification of each species has been made with respect to month & season of each study site. Using PRIMERv5 statistical package, the species diversity, species evenness, richness, similarity etc statistically been analyzed with respect to the time scale. The density of fauna is represented as number per cubic metre (No/m³) of water. Data are presented in the form of tables and graphs representing month & seasons for each study site.

6.3 Distribution and abundance of Macrobenthos in Mangrove ecosystem

This Chapter deals with the faunal composition which explains the general trends in distribution and abundance of macrobenthos over space & time. In all fourteen macrofaunal taxa have been identified and studied. Totally fourteen groups were identified and grouped under one umbrella of Macrobenthos. The density of fauna is represented as number per square metre (No/m²). A simple, comprehensive, graphical pattern has been drawn to show their monthly and seasonal variation giving their salient features of the benthic assemblage in different stations during the study period. Using PRIMERv5 statistical package, the species diversity, species evenness, richness, similarity etc statistically been analyzed with respect to the time scale. Data are presented in the form of tables and graphs representing months & seasons for each study site.

6.4 Distribution and abundance of Molluscs in Mangrove ecosystem

Totally thirty seven species belongs to nineteen families of Phylum mollusk were documented from the mangrove ecosystem of Kali estuary, Karwar. Majority of species
belongs to the class Pelecypoda (bivalves) followed by the class Gastropoda. Among bivalves, majority of them have commercially been exploited throughout the year which are taking care of livelihood of many people residing in and around the Kali basin. The molluscan species were identified, quantified and documented for each study site located in the mangrove ecosystem with respect to month and seasons. The density of fauna is represented as number per square metre (No/m²). Data are presented in the form of tables and graphs representing month & seasons for each study site.

6.5 Distribution and abundance of Crustaceans in Mangrove ecosystem

Under Crustacean fauna, two groups were observed namely Prawns (Penaeidae) and Crabs (Portunidae). Totally seven species of prawns (*Penaeus indicus, P. monodon, P. merguiensis, Metapenaeus affinis, M. dobsoni and M. monoceros*) were recorded. Crab fauna coprised by twelve species namely *Charybdis orientalis, Dotilla myctiroides, Leptodius exaratus, Metaporapsus messor, Portunus pelagicus, P. sanguinolentus, Sesarma quadrata, Scylla serrata, Uca annulipes, U.dussumieri, U. marionis* and *U. marionis nitidus*. These crustacean fauna showed great variation with space and time during the present study period. The density of these fauna is represented as number per ten square metre (No/10m²). Data are presented in the form of tables and graphs representing month & seasons for each study site.

6.6 Distribution and abundance of Fin fishes in Mangrove ecosystem

Totally twenty nine groups were identified which comprises fifty nine species and are presented in this chapter. In each study site, availability of these fin fishes have been documented and studied their variation in density with respect to month and season. It was observed that majority of fin fishes were found in the lower reaches of the estuary that is in study stations 1,2,3 &4 whereas some fishes were restricted to the station 5, which is fresh water locale. These fishes were shown seasonality in their abundance and distribution during the study period, which is discussed in detail in this chapter.
6.7 Fisheries

Detailed information is given about the fisheries of shell fishes (mollusks & arthropods) and fin fishes of Kali estuary/mangrove ecosystem for the period of thirteen months. Besides this, a brief mention is also made about the different type of crafts (boats) and gears (nets) which are employed in the fisheries. Species composition of shell fishes and fin fishes of commercial importance are discussed in detail.

6.8 Distribution and abundance of Woodborers in Mangrove ecosystem

A comparative study was made on the abundance and distribution of woodborers at five study stations located at different mangrove ecosystem of Kali estuary. Two groups namely mollusk and arthropod mainly represented this faunal community and were found to be site and seasonal specific in their abundance and were not distributed all along the estuary uniformly. Their monthly and seasonal variation in density has been documented in this chapter.

6.9 Distribution and abundance of Avifauna in Mangrove ecosystem

Abundance and distribution of avifaunal community in the mangrove ecosystem was studied. Morning and evening observations were made in the field to observe their nature, resident or waders, mode of feeding etc have been documented for the first time in the mangrove ecosystem. Based on the field study, a check list of avian fauna was prepared and reported in this chapter in detail.

Summary

In this chapter, the findings of the present study have been briefly discussed. The importance of the study, facts and figures are explained, variation of biotic and abiotic parameters of each station with respect to the space & time are discussed and justified. The salient feature of the present study is given in brief.
References

The relevant literatures which are referred as supporting statements, their relevance in the present text are cited in this chapter. For this purpose, the recent past periodicals, journals and text books and e-journals were referred and cited in the text. The latest information were also collected from different sources and have been incorporated in the text and the same are cited in this chapter.

In the light of all the above mentioned information and for deep felt necessity to investigate the faunal community of mangrove ecosystem of Kali estuary, a study comprising the interacting factors, abundance, distribution, community structure, ecological relationships, correlations among taxa and production in the mangrove environment was initiated. The results and discussions of this investigation are presented in six chapters. The data collected during the study period are tabulated and illustrated in the respective chapters to project the clear information of the study undertaken during the period of thirteen months.

Chapter 2
REVIEW OF LITERATURES

Karnataka has a coastline of about 320 km comprising three maritime districts namely, Uttara Kannada, Udupi and Dakshina Kannada. Uttara Kannada has a vast coastal line of 143 km which is blessed with five major riverine system, namely Kali, Gangavali, Aghanashini, Sharavathi and Venkatapur. River Kali forms one of the biggest riverine systems of this maritime district with a total stretch of 185 km comprising different biotopes like mangrove, backwater and estuarine complex. This estuarine complex exhibits remarkable characteristic features of physico-chemical and biological aspects within perhaps the shortest time and space scale. According to Pritchard (1967) an estuary can be defined as a semi enclosed coastal body of water which has a free connection with the open sea and within which sea water is considerably diluted with fresh water received from land runoff. The periodic flow of sea tides and land drainage are mainly responsible for the highly unstable physical, chemical and topographical features of this “Buffer zone” and subsequent creation of diversified habitats such as marshy areas, backwaters and estuarine areas where organic
matter is constantly built up in large quantity offering ideal biotic conditions to sustain considerable aquatic populations in general and benthos with sediments in particular.


Sediment texture in fact, is the parameter, which determines the abundance and diversity of benthic faunal groups of a said biotope within the grid of space and time. Hence, the sediment plays a vital role in monitoring the micro and macro organisms of the benthic realm. A considerable work has been carried out on sediment texture, its proportion and on temporo-spatial variation in different aquatic biotopes. Some of the pioneer investigations on sediments are those of Schalk (1938) who made a textural study of the outer beach of Cape Code, Massachusetts. Mahadevan (1955) made an intensive study of silt and clay texture of continental shelf and their hinderance in the industrial areas. El Wakeel et al., (1956) explained the methodology for the determination of organic carbon in marine muds. Other significant contributions are those by Morgans (1956) who predicted the significance of grain size in Brazos river bar and has reviewed the grain size parameters while Murthy et al., (1966) studied the seasonal changes in the characteristics of beach material.

Detailed study on the determination of the organic carbon and organic matter and their importance in fisheries have been extensively carried out by El Wakeel (1956), Rao (1960), Kallesha (1979), Paropakari (1979), Fernando (1981) and Fernando and Fernando (1988).


The sedimentological aspects on the riverine and estuarine biotopes in other parts of India have been widely studied by the Borole (1982), Ghosh (1989), Ramamurthy et al.,


Detailed study on the determination of the organic carbon and organic matter and their importance in fisheries have been extensively carried out by El Wakeel (1956), Rao (1960), Kallesha (1979), Paropakari (1979), Fernando (1981) and Fernando and Fernando (1988).

Very limited work has been carried out on Zooplankton community in the inshore and estuarine waters of Karwar. Ramamurthy (1965) has worked on the plankton of Karwar waters, Konnur (1981) reported plankton of Karwar water whereas a comprehensive study was carryout by Naik (1986) on zooplankton of Karwar bay and estuary, who studied the variation of zooplankton in relation to hydrographic conditions with respect to space and time. Later, no attempt has been on this community study either in the estuary or in mangrove ecosystem.

Significant research on estuarine benthos in general are those of Eggleton (1931), and Wolf (1974), while some others restricted their studies to estuarine macrofauna were Warwick and Price (1975), Young and Young (1978), Larsen (1979), Wildish and Kristamanson (1979). The specific detailed research on the most dominant benthic nematode group of estuarine was studied by Teal and Wieser (1966) and several others.

Specific investigation on the structure of the soft bottom community was made by Sanders (1960). Some other authors co-related the relationship between macro and meio fauna. A good amount of study was done by Mc Intyre (1968) who studied their ecology. Ansari et al (1977), Harkantra (1982), Kurian (1969), Parulekar, Nair and Paulinose
Richards and Riley (1967) and Seshappa (1953) studied on the sub littoral fauna of the Indian coasts.

In India, benthic studies on the west coast are comparatively more than east coast. Important works carried out by Kurian (1967 & 1971) and Sudarshan (1983). Most of the works on the benthos were done by Ansari et al. in late 80’s. Harkantra et al., (1982) on the population distribution of meiofauna in relation to some environmental features in the sandy intertidal region.

Literature available on sandy shore ecology of Karwar water was studied by Ansari(1978) Harkantra (1975) worked on the benthos of Kali estuary; Setty and Gupta (1972) worked on the foraminifera of the sediment of the Karwar coast. Sudarshan (1983) studied on the community ecology of the benthos of Karwar inshore area. Bhat (1984) has studied on the benthos of River Kali, Karwar whereas Mala (1994) has studied on the distribution and abundance of the benthos of Kali river restricted to the lower reaches. Sneha (1995) has studied on the meio-benthic production in Kali riverine systems. Amar (2005) has studied on the vertical distribution of benthos in the Kali estuary.

The molluscan diversity of River Kali was studied by earlier workers namely, Philipose, (1981) Harakantra, (1975); Neelakantan et al., (1981) and Naik and Neelakanta, (1990) but there is no information on this molluscan population from the mangrove ecosystem of Kali estuary. Mollusks are largely dominated by gastropods and bivalves. The gastropods includes snails, limpets etc. While the bivalves comprised by oysters, mussels and clams. They are commonly found attached to the plant parts of mangroves and also inhabit in the muddy bottoms of this swampy area. Sediments of virgin mangrove rich n mud and organic matter are characterized by high density of mollusks, while denuded or patch mangrove by low densities (Schrijvers et al., 1995). Mangroves provide ideal conditions for a high densities of gastropods, which inturn serve as food for other animals, particularly their veliger larvae because of their predatory nature, the gastropod occupy a central role in maintaining the function and productivity of mangrove and scavenging or cleaning the root system from the encrusting fauna suchas barnacles etc, the snails also serveas as an intermediate host for many trematode parasites (Schrijvers et al., 1995). As there is no information about mollusks in the mangrove ecosystem, the present work ws undertaken.
Kali estuary is one of the major estuarine systems of Uttara Kannada maritime district of Karnataka state, which drains its fresh water into the Arabian Sea near Karwar bay after meandering about 181 km. Our knowledge on the finfish community is fragmentary, with an earlier works of Nagaraj and Neelakantan (1980), Reddy (1990), Rajesh (1994). Recently the fin fish biodiversity and their abundance in the Kali estuary, Karwar was studied by Haragi et al., (2010). Hence, in the present study an attempt has been made to fill the lacunae, and project some information of this community’s biodiversity with space and time factor.

Several researchers around the globe have been paying lot of attention to the taxonomic aspects of the animals belonging to the two families (Teredinidae and Pholadidae) due to the economic significance attached (Krishna Pillai, 1961; Clapp and Kenk, 1963; Turner, 1966; Jones and Eltringham, 1971; Turner and Santhakumaran, 1989 and Cookson, 1991). Though considerable number of publications are available on the marine wood borer fauna occurring in different coastal habitats of India (Subba Rao et al., 1991; Santhakumaran, 1994; Balakrishnan Nair and Salim, 1994; Mathew and Govindan, 1995; Radhakrishnan et al., 1996; Kumar et al., 2000; Tarakanandha, 2003; Dev Roy, 2006; Pachu et al., 2008; Rao et al., 2008, 2009; Malik, 2009 and Balaji et al., 2009), a comprehensive list of wood boring fauna of India is presented to serve as a baseline information on the biodiversity of the country (Rao et al., 2008).

An investigation was carried out on the occurrence and distribution of marine wood-borers along the west coast of India, from Mangalore to Kandia. During the study, 12 spp. of Teredinidae, 1 sp. of Pholadidae, 3 spp. of Sphaeromatidae and 1 sp. of Limnoriidae were recorded. Among these, the most destructive species were Bankia campanellata, B. rochi, Lyrodus pedicellatus, Dicyathifer mannii, Teredo clappi, T. furcifera, Martesia striata and Sphaeroma terebrans. The destruction caused to timber constructions by these organisms was very severe and the problem is of great economic importance. Three species, Bankia nordi, Nototeredo edax and Teredothyra smithi, were reported for the first time from the west coast of India. Another species, Teredothyra matocotana, was recorded for the first time from Indian waters. The distribution of many species, like Nausitora hedleyi, Teredo clappi, Sphaeroma terebrans and S. annandalei is considerably extended further north. The
distribution pattern of all the molluscan and crustacean wood-borers, so far reported from Indian coasts, was discussed in detail.

Studies on avian community provide effective tools for monitoring forest in general and mangrove forest in particular. Evaluating bird communities of the mangrove forests to plan for biodiversity-friendly development is gaining significance. Ali and Ripley (1983) reported the avifauna of Indian subcontinent being represented by 2094 forms belonging to 1200 species of which 19.9% (417) forms are wetland birds (Rao et al., 1997). In recent past years, importance of bird diversity and its conservation has been emphasized and such studies are encouraged. Much work related to the avifaunal diversity has been done in temperate forests, while, a very limited data is available in the tropics in general and mangrove forest in particular.

Water birds being generally at or near the top of most wetland food chains are highly susceptible to habitat disturbance and are therefore food indicator of the general condition of wetland habitat (Kushlan, 1992 and Sonali, 2005). They also play a crucial role in mass and energy fluxes between terrestrial and aquatic food chains (Moreira, 1997).

In west coast of India, especially in mangrove ecosystems which harbor a fairly rich faunal and floral wealth are relatively unexplored. Only a few reports are available pertaining to the mangrove forests. Some studies on birds were conducted in the Goa region by Walia et al., 1996; Shanbhag et al., 2001 and Walia, 2000. A detailed report on the Birdlife at Santa Monic Lake, Goa was given by Walia et al (1996). Shanbhag et al., (2001) who have studied the impact of Konkan Railway Project on the avifauna of Carambolim Lake in Goa state. Limnological studies on some freshwater bodies of southern Tiswadi, Goa with special reference to waterfowl was conducted by Walia (2000).

In general, avifaunal studies have been carried out in and around the region of Uttara Kannada district of Karnataka state. But there is no studies have been made on avifaunal community of estuary or wetland area of this region. Hence to fill these lacunae, in the present investigation an attempt has been made to study the avifaunal community of Mangrove ecosystem exclusively for the period of thirteen months from January 2008 to January 2009.
Since there is no comprehensive work carried out on faunal community of mangrove ecosystem of Kali estuary, in the present investigation an attempt has been made to study the distribution and abundance of faunal community of this biotope (mangrove habitat of Kali estuary) with respect to different hydrographic and sediment parameters over the period of a year from January 2008 to January 2009.