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Mangroves and their faunal associates in Kerala with special reference to Northern Kerala, India

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RECORDS OF THE ZOOLOGICAL SURVEY OF INDIA OCCASIONAL PAPER

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CONTENTS

INTRODUCTION

Mangroves constitute a heterogeneous group of halophytic trees, shrubs and other plants colonizing tidal shores and brackish waters in the tropics and subtropics. The mangrove vegetation, as unique plant communities specially adapted to a particular environment, naturally sustains in muddy swamps in the intertidal areas on sheltered seacoasts, estuary-shores, including river deltas and bays of islands. The formation of this coastal wetland forest, often climaxed with impenetrable maze of woody vegetation, is the product of a holistic process and influence of the physical forces such as coastal geomorphology, climate, tidal kinetics, and period and quantity of freshwater inflow (Blasco, 1984; Thom, 1982). The mangrove-wetland systems are open systems, which exchange matter and energy between terrestrial and aquatic systems. Mangroves, often called 'Mangals' too, are unique vegetation veritably living at the edge of the sea where land and sea interlace, almost blurring the line dividing ocean and continent. Mangrove ecosystem ecologically functions as a complex ecotone or interface zone between the terrestrial and marine ecosystems, exemplifying diverse habitats, including microhabitats, characteristic of terrestrial, intertidal and aquatic environs. As an invaluable ecological system and for reasons of its rich biodiversity, economic and social standing for sustenance and survival of community people, sustainability of sea food, and shore-line stability, conservation of mangroves is of paramount importance (Deshmukh, 1991)

India with a coastline of 5700 km has approximately 4,87,100 ha of mangrove wetlands (FSI, 1999) which is about 3% of the worldwide extent of approximately 1,40,000 to 2,40,000 sq. km of mangrove systems, distributed in about 30 countries. The best development of mangroves in India is along the east coast with nearly 56.7% (2,75,800 ha) of the mangrove ecosystem of the country. Along the west coast of the country occur 23.5% (1,14,700 ha) of the Indian mangroves and the remaining 19.8% is around the Andaman and Nicobar islands (India). The east coast, unlike the west coast, is endowed with the largest mangrove wetlands developed on larger river deltas created by the major east flowing rivers of the country.

Kerala, one of the maritime states of the country with a coastline of about 590 km of the west coast, just over 10 % of the country's coastline, has only less than 1 % (about 4200 hectares), of India's total mangrove ecosystem. The very limited extent of mangroves is distributed in discrete and isolated patches, mostly confined to the small flats of delta, on the leeward faces of estuaries and embayment margins of the coast. Mangroves along the coast of Kerala are also less complicated in terms of tidal creek networks.

All along the Kerala coast there are a good number of small mangrove stands, though mostly in isolated patches, fringing the estuaries and backwaters (kayals), and around islets or along river margins in the coastline stretches. Kerala with its very limited extent of mangroves is in no way free from the current trends of degradation of mangrove systems

in the country. The scenario of the kind and trends of mangrove depletion in Kerala, in fact, renders a reflection of the typical mode of despoliation of this unique natural ecosystem in the country. Mangrove systems are one of the most threatened habitats in Kerala, as anywhere else in the country, or in the world.

The Western Ghats Field Research Station (WGFRS), Zoological Survey of India (ZSI), Calicut, with the objective of documenting the fauna associated with the mangroves, completed a scientific study on the coastal mangroves of northern Kerala, South India, as part of its scientific programme of work on ecosystem exploration and faunal documentation. The ZSI, Calicut, conducted its scientific, survey-study of the mangrove systems of the coastal districts, from Malappuram District to the northern most Kasaragod District, of northern Kerala, focusing on the mangrove systems confined to the northern Kerala (Map-1), from Ponnani in the Malappuram district to Thalapadi in the Kasaragod district (10° 46' 30" to 12° 45' 33" N). Northern Kerala was selected as study area primarily because the northern part of the coast has a higher share, nearly 70% of the state's mangrove systems, which include one or two much better and larger patches, than the stocks available in the southern coastal stretch of the state. Further, the mangrove systems in this part of the coast exhibited a higher grade of heterogeneity in their environmental settings and ecosystem features. Better operational feasibility for field exploration cum faunal collection programmes in a methodical manner, was an added advantage. Under the operational methodology, periodic field surveys were conducted to varied mangrove systems in north Kerala to make the collection of representative faunal samples and other ecological data available from the sites. However, the methods and accuracy of the mangrove ecosystem surveys undertaken were not in a directly comparable manner applicable to almost all small and moderately large patches. Because of the discrete and isolated nature of distribution of mangroves varied in structure and size of the stands, some optional approaches were also adopted in the surveys depending on the potential of the mangrove stands surveyed.

Detailed accounts of these mangrove systems, particularly the larger patches found in the districts, are presented giving thrust on faunal diversity features associated with them; the major faunal groups of both invertebrates and vertebrates observed and, or, collected have been dealt with in the study. An analysis on the faunal associates of mangroves in northern Kerala based on the collected and/ or observed data of fauna has also been discussed, with special reference to the faunal diversity richness in association with the mangrove ecosystem.

MANGROVES IN KERALA

Kerala, a small littoral state, is situated in the southwestern extremity of the Indian peninsula. It is flanked on one side by the Western Ghats, bordered by the states of Tamil Nadu and Karnataka, and on the other side by the Arabian Sea, all along on the west, with a coastline of 590 km long. The state with an area of about 38,863 km^2, seventeenth in area among the states of India, lies between North latitudes 8° 18' and 12° 48', and between East longitudes 74° 52' and 77° 24' The state has 14 districts, almost arrayed in south-to-north direction, 10 of them being coastal and 4 landlocked ones.

The physiography of the state is generally divisible into the Highlands, the Midlands and the Lowlands, including coastal plains. The proximity of the Western Ghats to the west coast makes land terrain more abruptly gradient in its features. The climate over the state is of a tropical monsoon type with seasonally excessive rainfall and hot summer. The period from March to the end of May is the hot season. It is followed with the southwest monsoon that continues till the middle of October. Then commences the northeast monsoon that lasts up to the end of February. The state experiences copious rains, major part of which is received during the southwest monsoon from June to September, which sets over the state by about 1st week of June. June and July are the rainiest months.

Mangrove wetlands have direct relationships to the factors of topographic diversity, variations of river discharges and the degree or amount of freshwater flow, sediment load and differences in tidal amplitudes, which determine the availability of nutrients to the vegetation and the type of mangroves at an intertidal site (Mitsch & Gosselink, 1986).

Coastal wetland systems of Kerala

The state's hydrologic potential associated with the coastal system constitutes 41 west flowing rivers (all seasonal, 4 of them moderately large, and others only minor ones), and the associated vast lacustrine system along the coast. The river systems mostly drain into the backwaters and estuaries in the coastal plains before emptying into the sea. The closer proximity of the Western Ghats to the west coast and the consequent descending gradients of land cause the river run offs in spate during the rainy monsoon period. As a result, the inflows from the uplands reaching the backwaters and estuaries discharge sizeable sediment load into the sea, with little deltaic accretion associated with the estuaries (Ramachandran Nair, 1986). During the dry season, the very same backwaters or lagoons intake the tides for considerable distance upriver in the coastal plains. The result is the seasonal fluctuations in salinity, rate of sedimentation and organic transport.

The role and relevance of the mangrove ecosystems in making the state's coastal waters, perhaps, richer in the marine fishery resources, however, cannot be negated. The state's mangrove ecosystems, though distributed in isolated patches, offer diverse habitat features by virtue of their localized environmental settings that are pertained to various west flowing river systems.

In the wetland systems of Kerala, the mangroves have had a significant role in making them a biodiversity rich zone by imparting more heterogeneity to its ecosystem features. The water resources of Kerala are among the most productive natural systems known in the country (Dileep, 2000). Diverse environmental settings of aquatic habitats in the coastal zone by virtue of their integral association with isolated patches of mangroves have made these aquatic habitats the centers of higher productivity of biodiversity resources.

Mangroves in Kerala : Past and present perspectives

Historical Perspectives : Palynological studies, based on the spores and pollen grains of mangroves discovered from the Quaternary deposits, have indicated the evidences of mangrove evolution in Kerala. The pollens of some of the characteristic species of *Avicennia*, *Lumnitzera*, *Sonneratia*, etc., from the Miocene deposits uncovered from the Warkalli (Varkala) beds of Kerala suggest the prevalence of mangrove and the humid tropical climate in this region since Miocene (Thanikaimoni, 1987). Palynological studies corroborate that the state is believed to have had the maximum representation of mangroves during the period about 11,000 years ago, and thereafter there had a descent in the distribution of mangrove stocks, major chunk of which having wiped out in the catastrophic climatic transition and marine regression. According to Blasco (1975), Kerala harbors only vestiges of mangroves, which indirectly evokes an insightful reference to the large-scale natural depletion of the mangrove systems having taken place during the erstwhile period, and also, probably, to the further trends of despoilation of this unique ecosystem facing anthropogenic interferences from the sub recent past onwards.

Current Perspectives : Evidences show the indications of rich mangrove system having existed along the coastal tracts of Kerala, supporting about 700 sq. km earlier (Ramachandran & Mohanan, 1990), but now having only vestiges or relicts of that stock. Basha (1992) in a survey of mangroves of Kerala recorded an area of about 16.31 sq. km. The recent estimate on mangroves of Kerala by Mohanan (1997) shows about 42 sq.km. There is confusion about the actual/exact extent of mangrove distribution in Kerala in the absence of a precise estimate of it.

In the context of Kerala, the coastal ecosystem is of prime importance. The state faces unique problem of pressure on land because of very high demographic pressure, which makes its indelible marks on the developmental scenario in agriculture, housing, industry, harbour, transport and telecommunication. Inevitably in the offing are more direct, ecosystem based intense socio-economic activities that might augment seafood production and processing, habitat housing owing to increase in coastal population, which may even touch to 5000 per sq.km. These contributory factors have the potential to further degrade and dwindle the presently available limited stock of mangrove systems in Kerala, unless and otherwise optimal counter measures are planned and implemented to conserve the mangrove ecosystem.

It is realized nowadays that mangrove systems are environmental buffers: on one count they bear the brunt of surging storms and tsunamis (giant sea-waves) of oceanic origin that wreak havoc on land, thereby protecting the terrestrial system as a natural Coast Guard, and on the other count offer common ecological and economic services for vast landscapes and people over longer time spans.

Review of literature

Awareness about the significance of mangrove ecosystems and the many unique features that they possess has, perhaps, paved the way for immense interest on them. But much of

the scientific literature generated in result of that zeal concerns mainly on floristic topics. Faunistic studies related to animal-mangrove association/interaction have not yet matched with the intensity and interest rendered to the floristic studies.

A review of literature on mangroves of Kerala shows a frugal and cursory approach on the database work on mangroves with studies being comparatively only a few, even on the floristic and structural topics, let alone on the faunal aspects, of mangroves.

Some studies on the faunal associates of mangrove wetlands from the region are the following ones. Santhakumaran (1986) studied on the marine woodborers of mangrove forests. Silas (1986) remarked on the significance of the mangrove ecosystem for the sustenance and survival of fry and larvae of fin fishes and crustaceans. Purushan (1989) discussed the importance of Puduvaipu mangrove wetlands as a potential brackish water fish seed resource. Thomas & Fernandez (1990) made studies on the seasonal variation of zooplankton of the Kumarakom mangroves, South India. NEST (1993) published an inventory of birds found at Kumarakom. Mohandas *et al* (1994) reported about 57 species of birds from the Asramam mangroves of Kollam. Sunil Kumar & Antony (1994) made some preliminary studies on the polychaete fauna of the mangrove areas of Cochin. Kurup (1996) reported several species from different mangrove systems found in the state. Jayson and Easa (2000) documented the vertebrate fauna in Mangalavanam Mangroves, Cochin and Jayson (2004) reported the avifauna associated with mangroves in various wetlands of Kerala. He reported about 41 species of birds from Mangalavanam mangroves, Cochin.

Extent of Area of mangroves

Among the maritime states of the country, Kerala State seldom figures out with appreciable extent of mangrove formation, despite having a long coastline of about 590 km all along its western side. Mangroves of only sporadic distribution are found along the coast, mostly confined to the margin waters of the leeward embayments of estuarine/brackish backwaters, including small or large mangrove strips found along the riversides in the coastal plains where tidal influx of estuarine/saline brackish waters is a daily feature. Mangroves along the coast of Kerala are also less complicated in terms of tidal creek networks, unlike the highly complex and dendritic mangrove systems formed on the larger delta of the major east flowing river systems on the east coast (Naskar & Mandal, 1999).

The mangrove vegetation of Kerala, encountered in isolated patches, along its coastal stretch of about 590 km long, has only a total area coverage of about 4200 hectares (42 km^2), which is just less than 1% of the India's total extent of mangrove ecosystem of 4,87,100 hectares (FSI, 1999). Whereas the state enjoys the potential of coastal stretch just over 10% of the country's coastline. The state's meager extent of mangrove stocks is too low to be compared with the state's much endowed forest wealth, covering an area of about 9400 km^2.

Based on the perusal of information from the old generation, elder people of the coastal community, and from other environment-based evidences (Ramachandran & Mohanan, 1990),

it is believed that the state was once gifted with a much larger extent of mangroves, estimated to be about 700 sq. km, along its coast. But, the major part of them having been already vanished, the state has presently got only the vestige stocks of the past (Blasco, 1975). Basha (1992) assessed an estimated extent of about 1631 hectares (16.31 sq. km) of potential mangroves occurring along Kerala coast. However, the latest estimate of the extent of mangrove cover of Kerala, based on fresh mappings and assessment of the mangrove areas in the state, is about 4200 hectares (Mohanan, 1997, 2005), the collective area including the degraded/degrading mangrove systems available in the state (vide, Table-1).

Table - 1

Sl. No.	Districts	Area (Ha)
1	Thiruvananthapuram	15
2	Kollam	15
3	Alappuzha	25
4	Kottayam	20
5	Ernanakulam	250
6	Thrissur	25
7	Malappuram	100
8	Kozhikode	200
9	Kannur	3500
10	Kasaragod	50
Total		4200

Source : Mohanan (1997, 2005)
District wise distribution of mangroves in Kerala

Vegetation and Zonation

The vegetation comprises of species-assemblages grouped as true mangroves, semi mangroves, and other plants that may not get submerged during high tides, but often thrive in saline soil, even withstanding brackish water stagnation for short periods. Basha (1992) has inventoried about 18 species of true mangroves, 23 species of semi-mangrove species and as many as 53 species constituting other plants (the non-mangrove species). Out of the 18 true mangrove species, about 9 species, that is 50%, are very common to both the southern and northern parts of Kerala coast. The species like *Avicennia marina* and *Kandelia candel* have better representation in northern Kerala, than in southern Kerala, whereas the species *Rhizophora mucronata* is mainly restricted to northern segment of the coast (Basha, *op. cit.*). Species such as *Excoecaria indica* and *Bruguiera parviflora* are, however, very rare, with their distribution being highly restricted to both the south and north parts of the coast. The mangrove vegetation along Kerala coast forms varied floral constitution, depending

on the hydro-topographic features of the associated wetland systems. An inventory list of mangrove flora observed in northern Kerala is provided in Table, 13.

Denser stands of mangroves in Kerala exhibit particular pattern of zonation of vegetation (Mohanan, 1997), with particular species congregated in a specific zone. Besides, zonation varies from locality to locality among the isolated patches (Vidyasagaran *et al,* 2004). In the mangroves of Kannur District, the proximal zone that is closest to the sea comprises of the predominating species like *Avicennia marina*, *Sonneratia caseolaris* and *Sonneratia alba*, while the intermediate zone occupies with species like *Rhizophora apiculata* and *Brugaria cylindrica*, whereas in the mangroves at Chettuvai (Thrissur District) and Ponnani (Malappuram District), the proximal zone is characterized by the predominance of *Aegiceras corniculatum* and *Acanthus ilicifolius*, often mixed with *Avicennia officinalis* in place of *Acanthus ilicifolius*, and the intermediate zone with species like *Bruguiera cylindrica* and *Rhizophora mucronata.*

Status of Mangroves in northern Kerala

Major areas of mangrove stands distributed in the coastal zone of northern Kerala, are shown in Map-1 & Table-1. A few large mangrove stands/strips could be observed and surveyed in the northern part of the Kerala coast. Exploratory surveys in the coastal areas in northern Kerala revealed the fact that the best mangrove stocks currently existing in the state is concentrated in the coastal districts of the northern Kerala.

Coastal areas in northern Kerala support a good many mangrove patches, some of which, e.g., mangroves at Ezhimala-Kunhimangalam area (Kannur District), Kumbla-Shiriya area (Kasaragod District), etc., are moderately large stands. Certain patches at Eranhipalam and Kottooly areas of Kozhikode District have been drastically altered since people-settlement times, while others at Ponnani-Thirur areas of Malappuram District are mostly gone or degraded owing to erratic and insufficient inflow run off to the coastal systems. Mangrove systems in Kozhikode District have been enormously wiped out owing to urban based developmental programmes, whereas in Malappuram District, considerable extent of mangroves in the coastal belt has been degraded or depleted by the resultant causes of environmental impacts from the consequences of extensive drainage programmes like irrigation/hydro-projects at the upstream areas of the Bharathapuzha River system, affecting the run off potential and periodicity of the inflow waters reaching the coastal zone in a highly insufficient and erratic rate. The coastal-zone degradation process like excessive extraction of sand deposits from the river bed and sandy-beach areas all along the coasts of these districts have further posed threats to the prevalence and perpetuity of this unique ecosystem.

Types of Mangroves

The physiographic conditions related to topography, substrate, freshwater hydrology and tidal action have determined the formation of varied types of mangroves in Kerala, depending on the characteristic site-settings of the mangrove stands. The mangrove patches are mostly

found along the leeward faces of the estuaries or embayments, and also seen in far inland areas along upriver margins that are within the ambit of tidal effect and influence. Hence mangroves along the Kerala coast, in general, are of the type, inner estuarine mangals, or River mangals (Banerjee & Rao, 1990) rather than of the outer estuarine mangals typically found along the eastern coast. Towards the more inland part of the hinterland where the topography is somewhat elevated and devoid of regular tidal flow, mangrove diversity transit to freshwater conditions to form transitional mangals, especially where salinity is less. Accordingly, there are fringe mangroves, overwash island-mangroves and riverine mangroves in Kerala (vide, Plate-1). The fringe mangroves are most common in Kerala, and almost all the larger and the richer stands of mangroves that exist nowadays in Kerala, are of this type (for example, the largest mangrove stands in and around the Kunhimangalam area in Kannur District). Patches of mangrove vegetation are found along the banks of the coastal stretch of rivers, sometimes adjoining the floodplains (Ezhome and Payangadi areas close to Kuppam (Payangadi) river in Kannur District). Sometimes, small creeks or pockets or far inland areas in the upriver vicinities or close to coastal waterways or canal works, harbour mangrove systems, which may apparently remain dry for considerable time, but remain intact-unless it is wantonly degraded by man-since the water table of area or site is generally just below surface (for example mangrove stands at Eranhipalam-Kottooly areas in Kozhikode District). Both the fringe and the riverine mangroves have significant productivity status as they turn out high amount of organic matter. The wetland bays or pockets, of small or large areas, associated with them are affected by freshwater runoff from adjacent upland areas and rivers, as well as sediments and nutrients transported by the river inflows. As such, these mangrove stands and their productive wetland system can greatly be affected by the hindrance of any kind in the upstream courses. In a few cases, the mangrove stands on mudflats found associated with small islands or islets (for example, the Thekkumbad island located in the estuarine waters of the Kuppam River) in the coastal zone remain flushed ("over washed") by tides daily during high tide (such mangrove stands on islands/islets are often termed 'over-wash island mangroves' – Mitsch and Gosselink, *op. cit.*). In the Thekkumbad Island, apart from the occurrence of 'over-wash' type of island mangroves on a mudflat extension, another long stretch of fringe mangroves, with well-developed stand-structure, is also observed along the western margin of the island.

A detailed account of the mangrove systems of northern Kerala, from Malappuram District to the northern most Kasaragod District, is presented giving thrust on floral and faunal features based on the structural complexity of the stands.

Mangroves in Malappuram District

Malappuram District has the mangrove systems of about 100 hectares, predominantly of sporadic and sparse stands. The existing mangrove stands, about 2.4% of the total extent of mangroves in the state, are in varying stages of degradation, except at a few sites associated with the Kadalundi River in its coastal stretch. The mangrove stands in the coastal areas of Malappuram District, based on their order of geographical placement, mainly include:

Sparse mangroves in and around Bharatapuzha (Ponnani) estuary, including small mangrove patches of Tirurpuzha, and the mangrove stands fringing Kadalundy River and its estuary.

Mangroves of Bharathapuzha estuary

The mudflats and the sand banks in the estuarine environs of the Bharathapuzh River-one of the largest west flowing rivers in Kerala, particularly in northern Kerala-have patchy remnants of mangroves. Such sparse vegetations are mostly found restricted to the sea mouth near Ponnani Port vicinities and Purathur area. The locales in and around the Vadickal Kadavu where the Tirurpuzha, a rivulet-tributary, joins Bharathapuzha also harbour moderate growth of mangrove patches. Mangroves associated with the Bharathapuzha estuary in and around the Ponnani, in general, portray a dismal picture of devastation exhibiting at many sites with only sparse regenerating clumps of mangroves.

As for the Bharathapuzha River, the hydrological features are characterised by the erratic period and quantity of its freshwater inflows even during the monsoon rainy season. Except for the occasions of incessant rains during monsoon period, i.e., June-September months of the year, most of the period, the river scarcely become swollen with seasonal inflows. As a result, the transport of sediments swept in the usual inflow run is at a very low rate. Interrupted stretches of sandy flats formed in the riverbed, with little mix-up of humus content in them, at a glance exemplify the impaired siltation/sedimentation process involved in the drainage system. At the same time the deep ditches and trenches with stagnating pools that are formed in the riverbed by the rampant sand mining process practiced by the people all along the river stretch in the plains, often exhibit thin deposits of trapped silt and other sediments. Thus very important physical and environmental factors that are fundamentally essential for the silt/sediment accretion at the river mouth are already below their threshold limits of aggradations, which, in turn, drastically affect he growth or regeneration of the debilitated stock of the mangrove patches in the estuarine and surrounding environs of the Bharathapuzha River. The better growth of this otherwise disrupted and degraded mangrove stands of this major river, are found along the river margins of the Tirurpuzha at Vadickal Kadavu and also located in the premises of the very same rivulet near to the town area of Tirur. The important mangrove plants are *Avicennia officinalis, Excoecaria agallocha, Dolichandrone spathaceae, Derris trifoliata,* etc. A small patch of very old *Rhizophora mucronata* thrives well at Vadickal kadavu area.

22 species of shorebirds and 12 species of sea birds could be recorded from these areas. Large aggregation of sea gulls, especially species like Brown headed Gull (*Larus brunnicephalus*), Black headed Gull (*L. ridibundus*), Pallas Gull (*L. ichthyaetus*), Heuglin's Gull (*L. argentatus*), etc., were sighted near Purathur area. Rare birds like Greater Flamingo (*Phoenicopterus roseus*), Oystercatcher (*Haematopus ostralegus*), Crab Plover (*Dromas ardeola*), and Masked Booby (*Sula dactylatra*) were also recorded from the locality. Nesting of Black billed tern (*Sterna acuticauda*), a globally threatened bird species was also recorded from the sand banks of Bharathapuzha. Large numbers of white necked Storks (*Ciconia episcopus*) and Open bill Storks (*Anastomus osciana*) were regularly sighted from the further

upstream areas close to the estuary. The breeding of small Pratincole (*Glareola lacteal*) and Little Ringed Plover (*Charadrius dubius*) has also been reported from the banks of Bharathapuzha. An assemblage of about two dozens of Reef Heron (*Egretta gularis*) was noted near the estuary, during March 2003. It is unfortunate to note that this mangrove associated wetlands and estuarine habitats are amply abused by the indiscrete and ruthless practice of poaching of these water birds.

Another conspicuous faunal community associated with the mangrove systems of this area is of mollusks. Mangrove associated wetlands or swamps near Ponnani Port area are well inhabited by a good assemblage of mollusks like *Telescopium telescopium* and *Cirrithidea cingulata*. *Meretrix meretrix* abounds in the estuarine environs of Purathur area and the local fishermen community makes use of this wealth for their subsistence. An eyesore to the health of this estuarine habitat system is the plundering of the sand deposits from the riverbed and estuarine areas through large-scale sand mining activities, which has been threatening the very life and existence of the healthy habitats of this river system.

Mangroves of Kadalundy River and estuary

Kadalunndy estuary is located between Tirur Taluk of Malappuram District and Kozhikode Taluk of Kozhikode District, bounded within 75°48' - 75°54' EL and 11°4'15" - 11°8'6" NL. The estuary of the Kadalundy River and the upriver margins (Map.1 A) contiguous to it are, perhaps, the best abode of mangroves in the Malappuram district. The estuarine marshland areas display the functional characteristics and role of a mangrove wetland system, albeit reflecting the ravages born by certain negative impacting forces in the recent past. During low tide, as the tidal floodwaters recede, the open area of the estuary up to the eastern end, delimited by the north-south railway track, gets exposed with its vast mudflats. The moderately large estuarine wetland system exhibits blocks or patches of mangroves edging around it, and on deltaic mounds falling close to the estuary, with varied complexity of vegetation, at isolated sites. Mangrove vegetation of better growth is found along the upriver margins contiguous to the estuary, and also fringing around a few small islets, namely, Balathuruth, Mannanmad, Neelattuthuruth, etc. The mangrove vegetation, however, does not exemplify the features of the healthy stand of mangroves, but mostly with woody-shrubby-thickets rendering an appearance indicative of the kind of degradation these mangrove patches have been undergoing due to the anthropogenic interferences. Although the mangrove plants comprise, primarily, of the species *Avicennia officinalis*, *A. marina*, *Bruguiera cylindrica*, *Kandelia candel*, etc., assorted assemblages of other halophytic species, like *Rhizophora mucronata*, and non halophytic species are also found along the river margins and around the islets. Small blocks of regenerating mangroves can also be seen on some of the prominent tidal flats formed in the estuary.

The mangroves and the mangrove wetland system in and around Kadalundy, offer congenial habitats or home grounds for many and varied faunal communities, which remain well integrated in a natural web of food chains, right from the detritus feeders and primary consumers (herbivores) to secondary, or tertiary consumers (carnivores). The mangroves

and the wetland system being located in, somewhat like, an isolated setting, comparatively much away from the human settlement areas, the ecosystem premises are amply used as the homing environs by a wide variety of animals, both invertebrates and vertebrates.

Other notable fauna of the wetlands include the mollusks, feeding along the marsh edges and the shallow waters. Large beds of *Meretrix meretrix*, *Villorita* sp., etc., were found thriving in the area. *Crassostrea madrasensis*, *Saccostrea cuculata*, *Telescopium telescopium*, *Cirrithedia cingulata*, *Dosthea violacea* etc., abound in the wetland habitats of the estuary. One ubiquitous form, a deposit feeder, found in the intertidal zone was the fiddler crab, *Uca* sp. Sporadic presence of the filter feeders like the mussel, *Mytilus* sp., was also noticed in the estuarine waters. The presence of marine gastropods, probably the forms often frequenting the shoreline and estuary environs, was also recorded from the estuarine premises.

Many of the fish species that are harvested commercially are associated with the estuarine wetlands, the degree of their dependence, however, varying widely with species. Most of the species, which are caught in coastal waters, spawn offshore, but their juveniles migrate to the estuarine-mangrove wetland systems, and use them as nursery areas. While some important species, e.g., *Mugil* sp., become permanent residents, others behave as transients that feed in wetland environs as long as the opportunity or requirement arises. There are also other oligohaline or estuarine fishes that complete their life cycle in the estuary, extending their range to the areas where the tidal waters flux with the freshwater influx, facilitating their opportunistic feeding. The members of the Freshwater herrings, such as *Dayella malabarica* (Day), *Ethirava fluviatilis* Deraniyagala are often abundant inhabiting estuaries and tidal upriver areas. These species are semi anadramous whose adults remain in the estuary fronts, pass through coastal tidal freshwater marshes on their spawning runs, and even to freshwater locales. The tidal freshwater areas, ideally mangrove fringing sites, are major nursery grounds for the juveniles of these species. As a result, they are often found in peak abundance in these waters. While in their growing phase foraging on invertebrates, they, in turn, become forage fish for many larger fish predators.

The Kadalundy mangrove wetlands are probably one among the best-known coastal sites for the abundance of avifauna, which is an indirect evidence for the diversity of the wetland habitat types, probably owing to the mangrove association of this wetland system being a key-influencing factor for the habitat heterogeneity. The mangroves and the associated wetlands provide good foraging ground for many species of migratory shore birds, gulls, turns and other resident waterfowls. The area has a bird diversity (observed and recorded) of as many as 106 species, of which 36 species are migrants. Most of them arrive in September and leave the estuary by April. Some of the shorebirds unrecorded by the renowned ornithologist Salim Ali, and therefore not included in his book "Birds of Kerala", are recorded from Kadalundy estuary.

The mangrove environs provide home ground and shelter for the Smooth-coated Otter, *Lutrogale perspicillata*. The mangrove thickets of the islet Neelattuthuruth indicated a few reclusive sites with dens of this mammal species. The animals like the Jackal, *Canis aureus*

and the Common Mongoose, *Herpestes edwardsii* (Geoffry) also take refuge in these mangroves.

Mangroves in Kozhikode District

Kozhikode district has a better distribution of mangrove stocks, and is third in position with an area-extent of about 200 hectares, out of 4200 hectares of mangroves in Kerala, which is, however, only 5% of the state's total mangrove extent (vide, Fig 1). The stands are in varied configuration owing to the impacts of degradation. The wanton degradation of mangrove systems in this district portrays a picture that evokes the careless attitude and disregard for mangrove wealth. The mangrove depletion at many sites in the district has gone to the extent that the functional ecosystem role of those stands has been narrowing down, over the years, with its telltale implications on hydrological and biotic features. A good part of the mangrove systems are thriving very much in the developmental limits of the urban settings of the district; the existing mangrove patches within these areas are steadily and systematically being removed in the guise of developmental activities of the district. The important mangrove growing areas in the district include the mangroves of the Beypore and Kallai River sides, mangroves at Eranhipalam-Kottooly areas close to the Canolly Canal, and the mangroves associated with the Kolavipalam-Kottapuzha estuary and backwater embayment.

Mangroves of Chaliyar and Kallai River sides/estuaries

The upriver stretches in continuum with the estuaries of the Chaliyar River (Beypore estuary) and the Kallai River have disrupted stretches of mangroves along their margins. The estuarine premises of these rivers are almost entirely devoid of mangroves, owing to varied kinds of pressures from urban settlements, port developmental and other industrial activities. As part of the port facility enhancement at Beypore Port, dredging cum deep trenching works of the river channel, at the estuary, is a recurring periodic practice, with the result that natural hydrologic process of silt/sediment deposition at the river mouth has, for ever, come to stand still, with the resultant stoppage of any kind of natural deltaic aggradation processes facilitating the growth or regeneration of mangroves. In the Kallai river, the natural process of alluvial sediment transport/deposition in the estuarine habitat environs have practically ceased because of the ubiquitous practice of a large number of timber saw-mills on either side of the river banks, dumping tons and tons of commercial timbers in the river stretch, thereby considerably blocking the sediment transport to the river estuary. The Kallai, from time immemorial associated with its timber industry has been a famous, trading timber to the entire Middle East.

Considerable stretch of both Kallai and Chaliyar riversides along their upriver courses from the estuaries, exhibits highly disrupted strip or fringe mangroves of varied structural configuration from shrubby thicket to woody vegetation. These patches are mostly predominated with the species *Avicennia officinalis* with an admixture assemblage of other halophytic plants in varied stages of growth, even with secondary level succession or stunted appearance.

Major fauna associated with the mangrove lined wetland system are the fishes, mostly the marine forms frequenting the brackish water systems in the tidal inflows. Local fishermen amply make use of the premises of mangrove lined river stretch for their fishing activities since fishes in good diversity (Table-9) and abundance are available in these stretches of both the rivers. Avifauna comprises mostly of water birds of resident population, majority of which also make use of the mangrove vegetation and the habitat environs associated with it for their shelter, foraging and progeny development and sustenance. These water birds depend not only on small fishes as their food of prey, but also on a host of invertebrates thriving in the exposed and secluded river banks, including the muddy-marsh wetland system adjoining the mangrove stands in the Kallai River.

Mangroves of Canolly Canal premises and Korapuzha River sides

Mangroves located in and around the Eranhipalam and Kottooly areas are associated with the Canolly Canal, the erstwhile water pathway (presently defunct), channeled in the coastal plains, within the Kozhikode City limits, linking the Kallai River with the next river on the north, namely the Korapuzha. The mangroves of the marshland swamps presently found in disrupted patches, in close proximity to the Canolly Canal at Eranhipalam, extending northward up to the Kottooly area, were once a part of an unbroken, much larger mangrove patch. This mangrove marsh wetland, in tandem with the Canolly Canal and other connected natural water links, had been, earlier, the major sinus receiving the floodwaters, draining it down through different channels to the rivers of Kallai and Korapuzha. It had a functional mangrove ecosystem well balanced with the physiographic and hydrological factors (features like topographic gradient, seasonal freshwater inflows and tidal influence and inflows from the river estuaries). No longer are there those attributes now to maintain the ecosystem in its earlier natural mode. The urban area expansion reclaiming vast area of the marsh wetland system, with replaced civil constructions such as buildings, roads, etc., has more or less altered and upset the hydro-topographic factors of the erstwhile healthy mangrove wetlands of the area, thus inescapably impairing its role and function of the ecosystem. The earlier, larger mangrove stands have systematically and steadily been defaced from the scene by the human factor, eventually displaying only the disrupted stands presently found restricted to the Eranhipalam-Kottooly areas. The mangrove growing environs at Eranhipalam better known nowadays as 'Kalipoika' as a large area adjoining the Canolly Canal and its adjunct, lake-like mangrove wetlands, has been greatly reclaimed and converted into a grand site for staging/ setting of cultural/commercial exhibition cum entertainment extravaganza.

Mangrove stands of these areas exhibit only sublevel growth as degrading factors have always been limiting the processes of succession maintaining them in the disturbed condition. Because of the large-scale reclamation works and other kinds of disturbances choking the mangrove ecosystem, the entire mangrove growing areas of the Eranhipalam Kottooly areas may apparently remain dry for considerable time. Yet the disturbed patches of mangroves thrive here since water table remains generally just below surface, obviously influenced by the tidal inflows into the small swamps and canal systems in the peripheral areas. The species

of *Avicennia, Rhizophora and Bruguiera*, and also some other taxa, constitute the plant community, with the structure and size varying at different sites within the whole mangrove system of the area concerned. The mangrove growths associated with the Canolly Canal at other sites are mostly in wiped-out condition except for the sparse remnants left at the fringing premises close to the canal's merging site with the Korapuzha. However, the Korapuzha River has mangroves in small patches, predominated with the degraded stands of the species of *Avicennia*, near Kuthirakkadu.

The faunal components of mangroves of these areas are not visibly apparent in their diversity, except for the fauna of invertebrates like insects and spiders associated with the mangrove vegetation. Entomofauna comprise many a number of chrysomelid and curculionid beetles. Arachnids comprised of different species of spiders, including one gregarious form colonizing in nests formed of bunched-up mangrove-twigs wrapped in their webs. A split-open nest of the colonizing species of spider exposed the remnants of different kinds of prey especially insect pests predated by the spider colony, thus inferring that they are efficient predator of entomofauna in the mangrove systems of this area. In the post monsoon season, however, the mangrove ecosystem in general reflects better diversity and abundance of organisms, especially of insect fauna comprising of readily distinguishable groups such as bees, bugs, beetles and butterflies.

This mangrove patches being surrounded by the human settlements and homestead vegetation, the reptilian faunal components such as the snakes and lizards that are associated with the homestead environs are also found inhabiting theses mangrove areas. The mangrove greenery during the post monsoon period attains lush look, and becomes agog with the diverse avifauna, including rare migratory bird-visitors, such as Common Teal, Blue-winged Teal, and the reddish-legged Stilts, to the Kalipoika mangrove wetlands. This mangrove ecosystem is believed to have been the ideal haunts of nearly about 150 birds, many of them breeding and foraging in these areas. The predatory animals like the Jackal, *Canis aureus* and the Common Mongoose, *Herpestes edwarsii*, in considerable numbers make use of theses mangrove environs for their food prowling and shelter.

The mangrove swamps associated with the mangroves become faunistically active with the onset of monsoon and thereafter when the swamps receive copious freshwater inflows from the land over washes. It is the time when the wetland environs visibly harbour the fauna like fishes. Shallow freshwater inlets and water paths to the mangrove system during this period are found with small freshwater fishes like *Puntius vittatus*, *Aplocheilus blocki*, *A. lineatus*, *Pseudosphromenes cupanus*, etc. These fish species and other invertebrate aquatic fauna like small worms and crustaceans (shrimps) constitute bulk of the food consumed by birds found during the period. During summer, the Canolly Canal and the small swamp systems become polluted with waste disposals and filth of urban cum human settlement origin, causing eutrophication of the canal waters thus drastically debilitating the wetland system for congenial faunal life. As contrary to this situation, the upriver brackish water areas of the Korapuzha are rich in fish diversity. The local fishing community people greatly depend on the brackish water fishery. The mangrove growing premises of this stretch of the

river are invariably found with fishermen engaged in their fishing activities. Even a fish-landing center for the brackish water fishery catches is in operation on the riverbank at Elathur.

Mangroves of Kolavipalam-Kottapuzha estuary

The Kottapuzha estuary (of the Kuttiady River) and the estuary embayments in the near about areas of the Kolavipalam beach harbour comparatively better, though fragmented, stands of mangroves edging the waters. The mangrove stands comprise mostly of the species, viz., *Sonneratia alba*, *Avicennia officinalis*, *Rhizophora apiculata*, *Bruguiera cylindrica,* etc.

The isolated settings of the area together with the sandy shore bed and the mangrove ecosystem constitute perhaps one of the ideal habitat sites in the entire coastal-based ecosystem of the state. The sandy beaches of the Kolavipalam, associated with the Kottapuzha estuary, is one of the potential turtle breeding ground of the endangered Olive Ridley Turtle, *Lepidocheilus olivacea.* Avifauna also abounds in the wetland systems associated with the integrated habitat environs of mangrove-estuarine systems and sandy beaches. Of the 105 species of birds recorded from these areas, about 46 species are winter migrants. Among the most abundant of them included Lesser Sand Plover (*Charadrius mangolus*), Whimbrel (*Numenius phaeopus*), Bartailed Godwit (*Limosa lapponica*), etc. Among the Kingfishers observed during the study included the rare black-capped Kingfisher (*Halcyon pileata*) also. Rare birds such as the Oyster Catcher (*Haematopus ostralegus*), Crab Plover (*Dromas ardeola)*, Avocet (*Recurvirostra avosetta*) Oriental Pratincole (*Glareola maldivarum*), Black tailed Godwit (*Limosa lapponica*), Terek Sandpiper (*Trinka terek*) Dunlin (*Calidris alpina*), Sanderling (*Calidris alba*), Grey Plover (*Pluvialis squatorola*) Eastern Knot (*Calidris tenuirostris*) and Sandwich Tern (*Sterna scandivicensis*), reported for the first from Kerala by Neelakantan (1986), could be observed visiting the Kottapuzha estuary and its mangrove ecosystem environs.

Among the mollusks, *Telescopium telescopium* and *Cirrithidea cingulata* were the predominant species found associated with the muddy sandy beds of the mangrove wetlands. Their empty shells were found occupied by Hermit crabs in innumerable number. Sporadic assemblages of *Crassostrea madrasensis* and *Saccostrea cuculata* were often observed on mud flats and shallow waters, close to the banks of the upriver stretch from the estuary site. Other mollusks like *Dostia violacea, Littorina scabra*, etc., were recorded from within the mangrove sites. *Meretrix meretrix* in considerable abundance often congregated to form thick beds at different sites of the mangrove wetlands. Bounteous occurrence of shells of *Donax scortum*, a marine species, accreted in thick deposits near sea mouth, extending even to much interior part of the estuary, is a ready resource for the lime industry.

The Kolavipalam beach and mangrove habitats are observed to be very vulnerable to the indiscriminate sand mining activities, posing great threats to the feeding cum roosting grounds of the migratory shore birds and other water fowls frequenting the Kottapuzha estuary. The

deleterious effect of sand mining in the beach premises has already affected the turtle-breeding site of the Kolavipalam beach, considered to be the prime nestling site of Olive Ridley turtles known from Kerala.

Mangroves of Mahe River

The mangrove formation found in the coastal vicinity of Mahe Town (a west coastal territory of Pondicherry State remaining enclaved within the coastal zone of Kerala) exhibit highly disturbed remnants of mangrove bushes, in small patches, restricted to the riversides and creeks of the Mahe River, otherwise called the Mayyazhipuzha, and comparatively better, though degraded, stands, in the upriver margins at Monthal area and further on the east in the Kerala territory.

The mangroves predominantly comprised of the species like *Avicennia officinalis, A. marina, Bruguiera cylindrica*, etc. The faunal dwellers included *Saccostrea cuculata* and the *Cassostrea madrasensis*, both edible oysters, inhabiting the muddy/sandy stretch of the river at this site. The mangrove dwelling mollusks like *Telescopium telescopium, Cirrithidea cingulata* were also found in abundance. The otters (*Lutrogale perspicillata*) used to be occassionaly sighted in these mangrove environs. During summer months large congregations of Little Cormorants (*Phalacrocorax carbo*), Little Egret (*Egretta garzetta*), Median Egrets (*Egretta intermedia*) and Pond Heron (*Ardeola grayii*) were sighted near the mangrove wetland premises. Red shanks (*Tringa totanus*) and Green shanks (*Tringa nebularia*) in small numbers were also observed and recorded during the field surveys.

Mangroves in Kannur District

As regards the mangrove distribution in Kerala, the coastal stretch of the northern district of Kannur exhibits the best and the richest stands presently existing in the state. The district has the potential distribution of about 83 % of the mangrove stocks of Kerala, having the extent of about 3500 (out of 4200) hectares (vide, Fig. 1). The mangroves associated with the Ezhimala and Kavvayi kayal surroundings, and the coastal areas of Kuppam (Payangadi) and Valapattanam Rivers are, perhaps, the prime centers of mangroves. Mangroves of appreciable growth are also found associated with the Dharmadampuzha, Anjarakandipuzha and the Eranjolipuzha near Dharmadam and Thalassery areas of the district. Further north are the mangroves of the Valappattanam River and the Kuppam River, with the notable vegetation-stands being distributed at the locales of Madakkara, Thekkumbad, Payangadi, Ezhom, etc. The Ezhimala-Kavvayi Kayal complex of mangroves associated with Ramapurampuzha, Chankurichal and Peruvamba River systems, predominantly centered in and around the areas of Kunhimangalam, in fact constitute the most potential mangrove genetic resource stocks of the state.

The large-scale occurrence of mangroves in the district, particularly the much older stands distributed in the above coastal areas, is reflective of the predominance of mangroves along the coast since the ancient period. The marine transgressions/retreats, repeatedly taken

place at wider intervals of time affecting the spatial-temporal changes in the coastal zone topography and the hydrologic dynamics associated with it in the bygone era (Ramachandran Nair, 1986)-which could have had a profound influence in the distribution of mangroves in this region-could conceivably and reasonably be linked to the probable depletion of the mangrove systems along the coast. The important mangrove systems of the Kannur District are :

1. Mangroves in and around Thalassery-Dharmadam Areas.
2. Mangroves of Ezhimala-Kavvayi Kayal complex.
3. Mangroves at Madakkara estuary.

Mangroves in and around Thalassery-Dharmadam Areas

The minor rivers namely Anjarakandy and Eranjoli form considerable extent of wetland network system that possesses small, sporadic stands of mangroves in and around Thalassery, and also at Melur, Mathikavu, Nettur, Koduvally areas near and around Dharmadam. Mangrove afforestation and augmentation works (i.e., planting of mangrove seedlings and their protection) initiated by the Forest Department (Kannur Division) at Koduvalli and Dharmadam areas is claimed to have been successful, with a survival rate of about 80% of the augmented plants. The mangroves in these areas predominantly include the species of *Avicennia officinalis, A. marina, Sonneratia alba, Rhizophora mucronata, Aegiceras corniculatum*, etc.

Considerable concentration of *Meretrix meretrix* and *Villorita* sp., forming large beds of harvestable nature, were observed near Moidupalam area close to sea. Edible oysters like *Crassostrea madrasensis* and *Saccostrea cucullata* are the other species of potential economic importance, widely being collected and marketed. The latter one, locally known as 'Kappeeri Muru', owing to its so called medicinal properties, is highly valued, and exported to the south-east Asian countries.

Among other faunal dwellers of the mangrove ecosystem, the semi aquatic bug, *Halobates galatea*, the member species of the only known genus representing the true marine insects, was observed and collected from the brackish waters close to the mangrove environs, of the Thalassery river. Radhakrishnan and Thirumalai (2004) have, thus, for the first time, reported the occurrence of this insect species from the coastal waters of Kerala. Many shore birds were observed abounding the environs of the marsh-mangrove wetland system of these areas. Among the birds sighted include wading birds like Little Egret, Median Egret, Large Egret, Grey Heron, Purple Heron, etc. Rare and endangered water birds like Darter (Snake bird), *Anhinga rufa* were occasionally sighted from the area. A roost of Flying Fox, *Pteropus giganteus*, was also observed on the tree-canopy of *Sonneratia alba* near Mathikavu area. Smooth coated Otter (*Lutrogale perspicillata*) was sighted occasionally near Melur area.

Coir industry along the banks of the rivers, intensive shrimp farming practices and large-scale sand mining activities cause great threat to the mangrove ecosystem in and around Thalassery.

Mangroves of Ezhimala-Kavvayi Kayal complex

The Kavvayi backwaters, otherwise called Kavvayi Kayal, an elongated water body extending all along parallel to the shoreline between Ezhimala and Nileswaram stretching about 21 km, formed by the drainages from four rivers namely Karingote, Nileswar, Kavvayi and Peruvamba, is perhaps the most conspicuous feature of the lacustrine system in the coastal tract of northern Kerala. The backwater system is found dotted with a few major islets namely, Edayilakad, Madackal, Vadakkekad, Chembantemedu, Oari, Thekkekad, Purathal, Kockal, etc. The protected shores and vast mudflats along the coast, and the sandy/muddy ridges surrounding the islets are found with potential stock of mangrove stands (Map.1 B). The stands exhibit varied types of mangroves with differential stand-structure and abundance at various localities, as varied as tall, widespread-canopied tree-stands to degraded shrubby thickets, or stunted or arrested vegetation at other places. The mangroves at Kockal show exemplary climax growth of trees of *Avicennia officinalis* having high girth and well branched canopy characteristics, in addition to well grown species like *Avicennia marina, Bruguiera cylindrica, Rhizophora apiculata, Excoecaria agallocha, Sonneratia caseolaris, Aegiceras corniculatum*, etc. The occurrence of *Lumnitzera racemosa* from this area has also been reported recently by Jafer and Radhakrishnan (2003).

The mangrove vegetation associated with the deltaic fringes of Kavvayi kayal, notably the stocks in and around the areas of Kunhimangalam, and on the fringe deltas of islets, is all that is left nowadays reckoning their extensive, lush and dense stock of the unique ecosystem, which had existed there once upon a time. The present system stands out only as a regenerating stock of a much disfigured mangrove treasure, constituting mostly of only mangroves with medium sized trees. However, in and around the Kunhimangalam areas, the sporadic occurrence of distinct and isolated giant mangrove trees, with hefty trunks having higher girth measures, and well spread branches and canopy, portrays-standing as living relicts-the glory of the older or ancient stock of mangroves of this region once upon a time. Quantitative structure of the true mangroves studied in terms of frequency, density and abundance related to the diversity of species in and around Kunhimangalam area, has revealed the species *Avicennia officinalis* having 80% frequency, with higher density of trees, among the true mangroves community (Khaleel, 2004).

The protected shores of the coast and the vast mudflats in the coast, and the sandy/ muddy ridges surrounding the islets are provided with potential stock of mangrove stands, unparallel of the sort in the entire Kerala. The stands exhibit varied types of mangroves with differential stands-structure and abundance at various localities, as varied as tall, wide spread canopied tree to degraded shrubby thickets, or stunted or arrested vegetation at other places. The mangroves at Kockal show exemplary climax growth of trees as already mentioned.

The mangrove wetland system and its surrounding aquatic habitat environs were observed to have an abundance of as many as 34 species of waterfowls. A notable observation was the sighting of two nest sites of white-bellied Sea Eagle (*Haliaeetus leucogaster*), an endangered sea eagle reported only from the northern part of Kerala. The Greater Spotted Eagle (*Aquila*

elanga) and Large Crested Tern (*Sterna bergii*) were the other important species sighted from the area.

The mangrove fringed coasts and the vast mudflats provided good potential for fisheries. The catches from the coastal estuarine cum backwaters exhibit good diversity and abundance of species. Local fisher folk greatly depend on the fisheries for their subsistence living. *Anadara granosa*, locally known as 'Kuttan Ilambacka', is regularly collected from the coastal wetland systems, along with species of *Meretrix*, *Paphia* and *Villorita*. Among the mollusks collected from the Kavvayi backwaters, *Anadara granosa* and *Paphia malabarica* are of high economic importance since their lime is said to be of very high quality.

Moderate congregations of *Crassostrea madrasensis* and *Saccostrea cucullata* were also observed. Sandy/muddy flats located at Mavilayi and Padanna areas are well known for the large scale abundance of *Paphia malabarica* and *Meretrix meretrix* respectively, which are heavily exploited at the commercial level by the fishermen during February-July period of the year. The mangrove growing islets are dominantly inhabited by species of mollusks like *Telescopium telescopium*, *Crithidia cingulata*, *Dostia violacea*, etc. *Saccostrea cucullata* richly abound the sea mouth, and in other areas of the wetlands. *Cassostrea madrasensis* also occurred in small and sparse concentrations. Sporadic assemblages of other seashells were also observed on the sand banks adjoining the estuarine waters of the Nileswaram River at Thaikadappuram.

The aquatic insects (Gerridae : Hemiptera) like *Rhagodotarsus kraeplini* Breddin and *Naboandelus signatus* Distant were observed and collected from the Pullangode area-site of Peruvamba River. As explained above, the coastal stretch of Peruvamba River, from Peruvamba to Chengoolichal area of Kunhimangalam, shelters the most important mangroves representing the largest as well as the richest mangrove stand presently existing in Kerala, with a stand structure comprising not only of the tallest mangroves of the species *Avicennia officinalis*, as high as up to 30 meters, along the river banks of Peruvamba, but also of the highly degraded stands of woody vegetation of arrested or stunted growth consisting of the species such as *Rhizophora apiculata*, *Avicennia marina*, *Bruguiera cylindrica*, *Aegiceras corniculatum*, *Acanthus ilicifolius*, etc. in the adjoining localities.

Among faunal components of mangrove-associated wetlands, large beds of *Meretrix meretrix*, *Villorita* sp., etc., were found near Chengurichal area. Others like *Teloscopium teloscopium*, *Cirithidea cingulata* were the common mollusks found within the mangrove wetlands. *Littorina* sp. was observed and collected from the vicinities of reinforced embankments and construction sites such as bridge sites. Mudflat banks of backwaters and the coastal uprivers were found thriving with sporadic congregations of *Saccostrea cucullata* and *Crassostrea madrasensis*.

The mining of shell deposits from the riverbed and the banks of Peruvamba, even from the adjoining wetlands and paddy cultivable floodplains, at Kandankali area was an activity of economic importance noticed during the field surveys. The major ingredients of the bed included, shells of species of *Paphia malabarica*, *Mactra sp.*, *Sunetta sp.*, *Meretrix sp.*,

Sanguinolaria sp., Placenta placenta, etc. The rich shell-deposits of these marine mollusks in and around these areas reflect the tell-tale evidence corroborating the bygone geomorphologic events linked to the marine transgressions and regressions that had taken place in the coastal zone of Kerala, probably during the time span stretching from Post Tertiary period to the recent geological past. The elder people of the local community are very categorical that they had gained this knowledge from their forefathers imbibed from and passed over to generation after generation.

Mangroves at Madakkara estuary

Madakkara is the coastal site wherein the Kuppam River from the north and the Valapattanam River from southeast join together and form the estuary (Madakkara estuary) before emptying into the sea (Map.1 C). The sandy mudflats at the confluence site of the rivers, facing the estuary, are fringed with profuse mangrove vegetation. Another site of mangrove vegetation is at Thekumbad, a small island located a little distance away from the estuary proper, in the channel of the Kuppam (Payangadi) River. The sandy-alluvium mudflats of the Thekumbad Island, at its southern and southwestern faces, also harbour good growth of mangroves. Mangrove vegetation of good growth also occurs on the deltaic fringes of Valapattanam River at Irinavu, and of Kuppam (Payangadi) River.

The vast mudflats formed behind the confluence of Valapattanam-Kuppam Rivers have rich mangrove formation, and despite rendering an isolated pattern of distribution, the adjacent areas of Irinavu in the riverbank of Valapattanam River, and the Thekkumbad Island falling in the estuarine part of the Kuppam River, also support good mangrove vegetation. Similarly, patchy mangrove bushes along the Kuppam river-embankment that separates the tidal marshes as well as the paddy-cultivable floodplain-areas of Ezhome and Cherukunnu villages altogether constitute very congenial grounds of notable habitat diversity for both flora and fauna. Floral assemblages, however, vary since the area is much altered in its land use pattern. The plant communities other than mangroves include mainly homestead vegetation comprising of coconut palm-groves and other riparian tree-shrub species. The mangrove patches though highly degraded in stand-structure, exhibit good potential of regeneration as is evident in the growth performance of some of the bushes. The mangrove stands in and around the Madakkara estuary, predominantly comprise of species like *Acanthus ilicifolius*, *Avicennia officinalis*, *Avicennia marina*, *Rhizophora mucronata*, *Bruguiera cylindrica*, *Sonneratia caseolaris*, etc. The occurrence of *Sonneratia alba* from this area has also been reported recently by Jafer and Radhakrishnan (2002).

The diversity of the aquatic habitat system of the whole area concerned in turn reflects a much better diversity of fauna. Avifauna abounds in these ideal settings of coastal wetland system. The sandy beaches, in fact flat seashore ridges, namely Azhikkal and Mattul in the south and north respectively, on either side of the river mouth, provide good foraging grounds for innumerable number of both resident and migratory birds. During the field observations in and around the areas of Madakkara mangrove-estuarine wetland systems, about 56 species of birds, under 7 families, were sighted and recorded. Migratory birds alone

constituted as many as 36 species, dominated by the members of the family Charadriidae with 21 species, followed by Larridae with 10 species. The resident raptor, Whitebellied Sea Eagle (*Haliaeetus leucogaster*) and the migratory Osprey (*Pandion haliaetus*) occur here. Most of the migratory shore birds arrive in August/September and leave by April/May. Brownheaded Gull (*Larus brunnicephalus*) and Lesser Sand Plover (*Charadrius mongolus*) are the most abundant ones among the migratory species. A large population of Brownheaded Gulls arrives in early winter (November) and return by April, with the population density attaining at the lowest ebb in the month of May. The rare migratory species, Sandwitch Tern (*Sterna sandvicencis*), has been noted here in considerable abundance. The Terek Sandpiper (*Tringa terek*), which prefers to forage in the environs of muddy-estuarine habitat near the mangroves, is poorly represented here. The mangrove environs of Madakkara offer ideal home grounds for the mammalian species like Smooth coated Otter (*Lutrogale perspicillata*), Jackal (*Canis aureus*) and Indian Mangoose (*Herpestes edwardsii*). The mangrove-bushes in the Thekkumbad Island with comparatively less disturbed habitat environs were observed to have the presence of a den of Smooth coated Otter, indicating a firm evidence of this mammal species. Sea snakes, especially the Hook-nosed Sea Snake (*Enhydrina schistosa*), are occasionally caught from the estuarine-mouth areas, trapped in the fishery catches of local fisher folks. Mudflats exposed during low tide were observed to harbour armies of populations of Fiddler Crabs (*Uca* sp.) and Hermit Crabs. Large mud crabs of species like *Scylla serrata*, *S. trancubarica*, *Neptunia pellagica* and *Sesarma* sp. were found in the fishery catches of fishermen. Vast mudflats flushed by tides were found to have the inhabitation of a good population of polychaete worms of the species *Namalycastis indica* (Southern). Mollusks like Horn shell, *Telescopium telescopium* (Linnaeus), and *Cerithidea (Cerithdeopsilla) cingulata*, etc., were found in large numbers, scattered on exposed mudflats of the estuary. The edible oysters like *Crassostrea madrasensis* and smaller bivalves like *Meretrix meretrix* were in large assemblages at scattered sites in the shoreline areas. Jelly fishes in considerable abundance, consisting of the Cassiopeid and Cepheid species such as *Cassiopea andromeda* (Forskal) and *Netrostoma coeulescens* Mass repectively, and the sporadic assemblage of Sea urchins, presumably an echinoid, *Echinodiscus* sp., etc., were also observed to foray into the estuarine waters of Madakkara. The mangrove-estuarine wetlands cum tidal marshes in and around the areas covering the locales of Madakkara, Payangadi, Ezhome, etc., altogether constitute a considerably richer zone of biodiversity potential in consideration of the complex and diverse environs of wetland habitats in the coastal belt of the Kannur District. The complex and diverse wetland habitats include the vast body of estuarine waters near to coastline, with its proximity to broad upriver stretch, followed by the vast area of the tidal marsh land, and the considerably large arable flood plains adjoining the marsh wetland system, altogether constituting ideal wetland homing zone for a vide variety of rich and diverse biotic communities. This congeniality factor of the habitat systems of this coastal stretch makes it a zone of richer and higher diversity of all kinds of flora and fauna - probably a reason why the faunal communities of the groups, such as the dominant ones like birds, fishes, mollusks, etc., closely observed here were found to have higher diversity and richness in their distributional occurrence here. Maximum diversity of fishes, about 92 species, was recorded, much similar to the higher abundance and representation of avifauna

sighted and recorded here. The fish diversity from these areas consisted of a number of fresh water species observed and recorded during the monsoon period of June-September months when flood plains were fully inundated under freshwater inflows and the salinity of the freshwater-tidal water-flux of the marsh wetlands and upriver waters came down to the level of as low as 0.5 parts per thousand.

During the flowering season of mangrove plants, a number of butterflies, wasps, Carpenter bees and honeybees were found visiting the mangrove flowers. Odonates (dragonflies and damselflies) are represented by *Diplocodes trivialis*, *Crocothemis servilia*, *Orthetrum sabina*, *Tholymis tillarga*, *Agriocnemis pygmaea*, *Ischnura aurora*, *Ceriagrion cerinorubellum* and *Pseudagrion microcephalum*. A notable observation was the epidemic outbreak of pest infestation by the notorious teak defoliator *Hyblaea peura* on mangrove vegetations of Avicennia at Payangadi, Thalassery coastal areas in Kannur District. The sandy beaches of Azhikkal and Mattul are known for the breeding of Olive Ridley Turtle, *Lepidochelys olivacea*.

The mangrove-estuarine wetlands and the ideal beach-habitat surroundings provide a good fishing ground for the local people. This coastal zone is well known for its fishery potential of both finfish and shellfish. As such large-scale fishery activity-for the collection of mussels, prawns and crabs, besides intensive local fishery operations for fish catching from estuarine cum coastal marine waters-is the major occupation of the local community people.

The local people have found much more dependence on many mangrove floras, especially the species like *Avicennia officinalis*, *A. marina*, *Sonneratia caseolaris* and *S. alba*, as the leaves of these species are known to be alternate fodder for their cattle, and, therefore, periodically collected. Immediately after the beginning of the post monsoon season, people of these areas usually collect the nutrient rich sediments and mud from the mudflats for manuring the coconut plantation, the process of which is considered to provide better yield of crops, thus promoting the economy of the people. Large areas of marshes at Irinavu and some premises of the Madakkara estuarine mudflats are used by the local community people for retting coconut husk for the localized coir-industry.

Mangroves in Kasaragod District

Kasaragod District, the northernmost district of Kerala, has the least potential for the mangroves in northern Kerala, which is having only 50 hectares of mangrove stands sporadically distributed along the margins of a few minor river systems, namely the Kavvayipuzha, Karingote River, Thuruthipuzha, Karyamkodupuzha and Nileswaram River, with isolated stands being close to coastline. The mudflats on the river mouth of Manjeswaram River also have appreciable mangrove formation. The riverbanks in the lower reaches of the rivers Kumbala, Shiriya, and Mogral also possess some stocks of mangroves. The mangrove system of the district is mainly associated with the Kumbala-Shiriya Rivers at their lower reaches.

Mangroves of Kumbala-Shiriya Rivers

The confluence of Kumbla and Shiriya Rivers at Kozhipady Kadappuram is characterised by vast stretch of mudflats, which harbour lush growth of mangroves. The species are predominantly comprised of *Avicennia officinalis* and *Rhizophora mucronata*, associated with *Aegiceras corniculatum*, *Excoecaria agallocha, Acanthus ilicifolius*, etc., and the stand constituted by them become the most important mangrove sites in the district.

The mudflats exposed during low tide provide good foraging grounds for innumerable number of shorebirds, particularly Green Shanks (*Tringa nebularia*), Red Shanks (*Tringa tetanus*), Lesser Sand Plover (*Charadrius mongolus*), Large Sand Plover (*Charadrius leschenaultii*), Common Sand Piper (*Tringa hypoleucos*), etc. Mollusks such as *Telescopium telescopium, Cirithidea cingulata* were observed in abundance. *Dostia violacea*, a mangrove associated mollusk species was also observed within the mangroves. *Littorina* sp., *Stenothyra* sp. were also observed and recorded. Empty shells of *Meretrix meretrix, Andara granosa, Paphia* sp., *Villorita* sp., etc., were also collected from the area. Moderate congregations of *Crassostrea madrasensis* and *Saccostrea cucullata* were also observed. Sandy/muddy flats located at Mavilayi and Padanna areas are well known for the large scale abundance of *Paphia malabarica* and *Meretrix meretrix* respectively, which are heavily exploited at the commercial level by the fishermen during February-July period of the year. The mangrove growing islets are dominantly inhabited by species like *Telescopium telescopium* and *Crithidia cingulata*, especially at sea mouth. *Crassostrea madrasensis* was also found in other areas.

LAND USE AND EFFECTS ON MANGROVES IN KERALA

In Kerala, most of the areas under mangrove cover, about 89 %, are owned by private parties (Swaropanandan & Muraleedharan, 2004). Considerable extent of coastal wetlands, including especially the mangroves, were degraded or destroyed by filling for land developments or dredging for navigational or harbour development programmes. In Kerala, a highly populous state in the country, since the early period of known memory of man, the coastal wetland systems have been under severe misuse, initially in the form of alteration of natural wetland and mangrove systems into wet farmlands, and later with a multi-pronged motivation in order to quench the many wanton socio-economic needs of man. Considerable stocks of mangrove wealth had been wiped out from their natural abodes in the past. Intensification of agriculture, over harvesting or clearing of woody vegetation, spread of human settlement, construction of road and rail routes, and ports constitute some principal forces behind changes in land use. The coastal zone all along Kerala has been invariably under the grip of these landscape changes which have led to the sweeping degradation and fragmentation of mangrove wetland systems greatly affecting the wetland hydrology, vegetation cover and the ecosystem linkages of an interface zone (ecotone) at a level so broad that it appears as a commonplace phenomenon of (Plate-5).

There are large and small freshwater wetland areas along the Kerala coast (for example, paddy cultivable 'Kuttanad' wetlands in South Kerala, 'Kole wetlands in Central

Kerala, and 'Kaipad' wetlands in North Kerala), which have been known to be the main granaries of Kerala since the period of beginnings of the age-old settlements in these areas. Clearing of natural vegetation, including the riverside mangroves in the coast, close to marshlands, had been a practice in the early history of landscape changes. Sparse small patches of mangrove bushes found in the embankment-vicinities of Payangadi River close to the areas of Kaipad paddy cultivable flood plains as well as tidal marshes, remain as vestiges of vegetation of the earlier mangrove stands after the alteration of the landscape for the purposes of agriculture and human settlements in the erstwhile period.

From the early period notion of the conversion of coastal wetlands for agriculture use, has in the recent period onwards shifted to the newer ideas of draining and filling of wetlands (reclamation) for urban and industrial developmental purposes. The rate of mangrove wetland loss appears closely tied to population density, since coastal zone of Kerala has higher population density and therefore receives greater pressure as sites for development expansion.

Canolly Canal linking the intercoastal stretch of Kallai and Korapuzha Rivers had been made primarily for providing water transportation access to ports and other important urban locales in the early period. The rich mangrove stands in and around the Eranhipalam-Kottooly areas in the past seem to have had a trend of gradual depletion since the period of construction and the functional operation of the Canolly Canal water pathway. The canal dredged through the belt-area of the major mangrove wetland system of the Eranhipalam-Kottooly areas, appears to have been a prime cause that had initiated the process of degradation of this major block of mangroves. When highways too have come into operation, nearly close and parallel to almost all along its course, the canal pathway has become almost defunct as far as its primary purpose-i.e., water transport-is concerned. The utility of the canal system, nowadays, is as a storm-water drainage during the rainy June-September months, and in the off-season as a waste disposal duct receiving all kinds of sewage-effluents of urban origin as it courses through heavily populated coastal plains. However, the highway developments and the consequent urban area development activities, coupled with the related logistic drive of the increasing population, have been steadily eroding the mangrove features of the areas over the recent years. The large-scale degradation of the mangrove system in and around the Eranhipalam-Kottooly areas infers how these highway and related construction activities have disrupted or interfered with this mangrove ecosystem's most important ecological functions by thwarting the hydrologic conditions of a fine mangrove system as that had once thrived in this area. The wetlands, especially the mangrove systems, are believed to have the ability to cleanse water. However, wetlands are often qualitatively altered by overdose of pollutants from land run off through river inflows, or local run off. Mangrove pockets in the vicinities of urban areas, for example, mangrove swamps at Eranhipalam areas and also the water-canal network system in the city premises of Kozhikode, are many a time observed with eutrophication, with very low or little species components. In certain areas of the wetlands, including the isolated pockets of mangrove swamps in the coastal zone, heavy metals and other toxic organic compounds are added to the lot of polluting ingredients, which could interfere in the growth and other vital biological processes of the inhabiting biota of the

natural habitat system. Even vegetation remains with stunted or arrested growth at pockets wherein there is very high dose of such pollutants.

In the coastal plains of Kerala, the lowland floodplains are made use for paddy cultivation as soon as the monsoon spate of freshwater inflows ebb. Another cause that has been making the decimation of mangrove sites was the large scale mismanagement of landscape by converting and clearing mangroves in order to cut open large pond like systems in the coastal belts for shrimp farming.

OBSERVATIONS AND DISCUSSION

Mangroves as a group of plants or their communities, is easily understandable as well as definable; whereas such a distinction may cause some confusion when faunal components of mangrove system are dealt with. Mangrove fauna are generally termed for the faunal components, or communities associated with the mangroves, which are, however, not exclusive to the mangroves or mangrove wetland ecosystem. Mangrove faunal associates (vide, Tables: 2-12; Plates: 2-4) may include the marine, terrestrial, and intertidal fauna, which are not obligatory dependent on mangroves, but facultative/optional settlers in the mangrove habitat, taking advantage for one time or other, for their food and, or, shelter.

Studies on the faunal associates of mangrove ecosystem of the country are not many. In comparison to our understanding about the status of floral composition of mangroves, the knowledge about diversity and richness of fauna associated with them is far from adequate, let alone about their ecological interrelationship with this unique ecosystem. In the global perspective, Rao (1987) has documented a diversity of species of about 397 fishes, 259 crabs, 256 mollusks, 450 insects and 250 mammals, in addition to 193 plants associated with the mangrove ecosystem. In a compiled data on faunal diversity in mangrove forests of India, Upadhyay *et al.* (2002) have made an estimated account of species under faunal groups, viz., Crustacea (229 species), Molluscs (212 species), Wood borers (25 species), Fishes (185 species), Reptiles (39 species) Birds (117 species), Mammals (36 species) and Microbenthos (111species).

Many informative observations were made and recorded pertaining to the faunal associates of mangrove systems in the northern Kerala, during the mangrove ecosystem investigations conducted in the northern Kerala. The major faunal components observed and recorded in connection with the investigations are illustrated below. Data documentation on the diversity and, or, ecology of organisms observed and studied are, however, not strictly based on the statistical sampling analyses, but rather, based on the random samplings made then there during the time of programmes. But, as far as possible, attempts were made to observe, record and, or, collect whatever major faunal components were found in the field, as well making representative faunal collections, through random sampling modes, of possible faunal components available in the field.

As expected in the general faunal investigative programmes, there were limitations to make the objective observations and collection/recording of the attributes/aspects of fauna

pertaining to the lower invertebrate groups, especially of members of the lower phyla/groups such as Protozoa, Porifera, Platyhelminthes, etc. As such survey cum collection study mainly deal with the other major, dominant faunal components of the groups like annelids, mollusks and arthropods, among invertebrates, and fishes and birds among vertebrates.

The faunal components collected/observed in connection with the study are inventoried in table-wise data (vide, Tables 2-12). The mangrove flora of northern Kerala has been enlisted in the Table, 13. Faunal composition/diversity of certain groups of fauna recorded and studied has been depicted in Figs. 1-5. Besides, 5 plates of photographs showing the various types of mangrove stands, mangrove faunal associates and different kinds of degradation of mangrove ecosystem in northern Kerala have been incorporated.

Annelida (Polychaeta)

In almost all the areas of mangrove-estuarine ecosystem areas, the mudflats and the estuarine deltaic fringes, flushed by the rhythmic tides were found to harbour the population, comprising of considerably a large number of individuals even in a small area-extent, of a common species of polychaete worm. Among annelids as mud dwellers, from the mangrove-estuarine areas include polychaetes such as *Namalycastis indica* (Southern), *Tylonnereis bogoyawlenskyi* Fauvel, *Dendronernereis arborifera* Peters and *Nereis glandicincta* (Southern) of the family Nereidae; *Naphtys oligobranchia* Southern of the family Nephtyidae; *Glycera alba* (Muller) of the family Glyceridae; *Marphysa sanguinea* (Montagu) of the family Eunicidae (Table-7). The polychaetes with their shorter life spans and faster growth are important component in the faunal biomass productivity and fishes heavily predate on them.

Arachnida

The aerial environs of the mangroves, comprising mainly of the part of mangrove vegetation above the surface of water and the terrestrial habitat environs close to the vegetation, were found to harbour the communities of other invertebrate-fauna, particularly arachnids and insects. Arachnids that were observed/recorded and collected included mostly spiders, comprising of 24 species (Table-2 & Plate-3). Of these, 13 species were recorded from the mangrove-environs in Kannur District, followed by the representations of species from the respective mangrove systems, 9 species from Kozhikode District, 7 from Kasaragod District and 5 species from Malappuram District. Sample collections also contained a few specimens, one set from the Kottapuzha estuarine mangrove, and another set from the Thekkumbad mangroves, which on careful scrutiny of taxonomic systematics were found to belong to two species new to science; their scientific illustration cum description are being almost completed by the concerned experts.

Insecta

The mangrove systems were found to have a bevy of activities by insects such as bees, bugs, beetles and butterflies and odonates, in addition to an assemblage of other groups of

insects during the post monsoon period, notably during the lush-green phase of growth, followed by the flowering phase of mangrove floras. Bugs and beetles comprised predominantly of insect pests infesting the floral components one kind or other (e.g., sapsuckers, leaf-feeders, etc.). Yet another group of insects which naturally checked the population build up of these insect pests, thus biologically benefiting the mangrove floras from heavy pest infestation, was the so called parasitoids whose population too simultaneously increased in tune with the pest build up. Study of a taxonomic group of parasitoids, namely Chalcidoidea (Order : Hymenoptera), constituting hymenopterans well known for their potential as efficient agents of biological control, rendered a diversity spectrum of 10species (Table-3) based on the collections of faunal samples from mangrove vegetations from different places in northern Kerala. Besides, the expert who studied and identified the chalcidoids from the sample fauna also remarked about the possibility of having a new species in the sample.

The butterflies occurring in the environs of mangrove ecosystem were found to have a diversity of as many as 33 species (Table-5). Jafer and Radhakrishnan (2001) reported the observation of butterflies flitting on the mangrove species *Excoecaria agallocha* L. One exceptional observation of significant importance made in the survey study was that of the epidemic infestation of the larval teak defoliator (vide, Plate-5), namely *Hyblaea peura*-a lepidopteran pest-species-on mangrove stands at various places in Payangadi and Thalassery areas of the Kannur district (Jafer and Radhakrishnan, 2004). The fact that mangrove plant-species becomes prone to the attack of the teak defoliator, *Hyblaea peura*, is of significant importance.

The mangrove wetlands, like freshwater habitat environs, do attract hordes of dragon and damselflies. However, as regards their diversity, their ecology or behavioural patterns related to their presence in the premises of mangrove wetlands involve intricacies of something more than that of their mere habituated foraging instincts, which needs to be studied in depth. In order to have an idea about their presence in the premises of a backwater system, in northern Kerala, Jafer and Sonia- *in press* - have documented about a diversity of 21 species associated with a backwater swamp in northern Kerala. In the present study, a diversity of about 23 species of Odonata (Table-4) was found to occur in the mangrove wetland premises in northern Kerala.

Mollusca

Molluskan faunal elements of mangrove ecosystem and its estuarine premises are notable in the northern Kerala. Mollusks, living as filter as well as deposit feeders, constituted one of the major groups of faunal component or community among mud dwellers associated with the mangrove-marsh wetlands. On the intertidal mudflats flushed by tides, a good many mollusks are the dominant organisms, sometimes found along with crustaceans also. Environmental factors such as sediment grain size, tidal elevation, organic carbon and nitrogen, and bacterial density are considered to set limits for distribution and abundance of most of these deposit feeders. Sand flats also support large populations of bivalves of some species;

some forms live buried within mud, with their protruding siphons above surface when they are covered by the tide. However, their distribution is generally patchy. A number of bivalve mollusks have been recognized as key components of the ecosystem. In the case of mollusks, the wide range of possible salinity and temperature combinations is considered as the probable one key reason for the success of many species in sandy/mudflat environs associated with the mangrove-estuarine systems.

Mangrove-estuarine habitat environs in northern Kerala were found to have a diversity of about 29 species (Table-6). Of these, the species such as *Nerita (Dostia) violacea* Gmelin, *Pila virens* (Lamarck), *Littorina (Littorinopsis) scabra scabra* (Linnaeus), *Cerithidea (Cerithideopsilla) cingulata* Gmelin, *Telescopium telescopium* (Linnaeus), *Turitella attenuata* Reeve, *T. duplicata* (Linnaeus), *Natica tigrina* (Roeding), *Anadara granosa* (Linnaeus), *Crassostrea madrasensis, Saccostrea cucullata* (Born), *Donax (Hecuba) scortum* (Linnaeus), *Meretrix meretrix* (Linnaeus) and *Paphia malabarica* (Schroeter) were observed to have their population distribution all along their corresponding habitat environs in all the four districts of northern Kerala. During the peak rainy season and shortly after that, the fresh water species *Pila virens* (Lamarck) was observed to occur in considerable abundance in the paddy cultivable floodplain areas adjoining the mangrove wetlands of Ezhome village (Kannur District) in the Kuppam River premises.

Among varied molluscan fauna of the mangrove-estuarine environs, the species *Neritina (Dostia) violacea* (Gmelin) is a common gastropod species found in estuaries and back waters. The species of *Littorina (Littorinopsis) melanostoma* Gray and *Littorina (Littorinopsis) scabra scabra* (Linnaeus) are found amidst mangrove vegetation, often seen attached to stems and leaves of trees; so also are species like *Cerithidea (Cerithideopsilla) cingulata* Gmelin, *Telescopium telescopium* (Linnaeus), besides their habitation on mudy/sandyflats. Empty shells of these two latter species are also often occupied for protection by the fiddler crabs, *Uca* spp., *Turritella acutanula* (Linnaeus) commonly known as screw shell or turret shells are found occurring buried in the sandy bottoms, close to estuarine mouth. The members like *Thiara (Terebia) lineata* (Gray) and *Thiara (Thiara) scabra* (Muller) of family Thiaridae, though generally found in fresh waters, also occur in brackish waters.

Species like *Anadara granosa*, *Meretrix meretrix,* etc., considerably abounded in the coastal wetland systems, forming large beds of their deposits, which have, thus earned great economic importance in lime industry. These two species, along with *Paphia malabarica*, are also well known in the coastal areas for their edible value. Shell-deposits of sporadic occurrence, formed of complex assemblages of a good many species, including *Meretrix casta*, and other species, in their sub fossil forms, forming economically exploitable deposits down to a depth of a few meters, or even more, were observed at a few places in the premises of the lacustrine areas in the coastal belt of Kannur District inferring the antiquity of these environs having been an integral part of the coastal marine ecosystem, or an area having experienced marine excursions in the recent geological past.

Crustacea

The aquatic habitats associated with the mangrove wetlands and its surroundings, including estuaries and vast areas of brackish waters (lagoons of Kayal, and the upriver stretch close to these areas) supported and sheltered the populations of communities of Crustacea. Under these faunal categories, the communities of crabs and shrimps dominated the scene. In the present study, out of a good many individuals constituting different populations, at varied environs of mangrove-system and the close by estuarine/brackish water areas, observed and collected, comprised about 20 species of crabs (Table-8). A freshwater species (*Cylidrotelphusa steniops* Alcock) was also spotted and collected from the flooding freshwater-tidal water flux, with very low salinity, during the prime season of monsoon. Among the species having considerable abundance in the habitat environs of mangrove-estuarine mudflats included the ubiquitous fiddler crab *Uca lactea* (de Haan), with its army-like population. Other forms like the very common edible species such as *Portunus pelagicus* (Linnaeus) and *P. sanguinolentus* (Herbst), *Charybdis (Charybdis) feriatus* (Linnaeus), etc., which support good crab fishery all along the coastal belts of Kerala, including in the state's northern segment, considerably abounded in their occurrence. Species like *Scylla serrata* (Forskal) and *S. trancubarica* (Fabricius) were observed occupying the banks and mudflats in the shallow fringe waters. The shrimp community was found to predominate with the penaeid species *Metapenaaeus dobsoni* (Miers) and *Penaeus indicus* H. Milne Edwards, followed by *Penaeus monodon* Fabricius, and as well the Palaemonid species *Macrobrachium rosenbergii* (deMan). All these species are highly valued for their shrimp fishery potential all along the coast of Kerala.

Pisces

The major group of fauna that dominated the aquatic habitats associated with the mangrove-estuarine systems was that of fishes. In the present faunal survey cum study, the mangrove-estuarine and backwater systems of northern Kerala is observed to have the fish faunal diversity of as many as 122 species (Table-9). This spectrum of diversity included a number of species of marine fishes exhibiting notable preference or affinity to occupy the mangrove-estuarine systems and backwaters for feeding and breeding purposes. Semi-anadromous fishes, e.g., some serranids, pawns in the coastal tidal freshwater marsh as well as oligohaline mangrove-marsh waters; juveniles remain in this habitat along mangrove-marsh edges, moving gradually downstream to the lower estuary and near shore zone as they mature. Some of the juveniles of serranids like *Epinephelus* spp. and pomacentrids like *Abudefduf* spp. could be collected from the coastal mangrove-marsh wetlands and studied. Some ecological attributes regarding the vagrant visitations of the species *Abudefduf sordidus* (Forskal) to the mangrove-lined estuary bay (Kottapuzha estuary in Kohikode District) have been observed and documented (Gopi and Jafer, 2003). Among the eels-fishes usually catadromous, spawning in the oceans but returning to freshwater-apart from the occurrences of some of the anguillid, muraenid and ophichthid species, which occasionally enter brackish and freshwaters, even muraenesocid species (pike congers), which are normally marine, were found to foray frequently into the mangrove-estuarine marsh wetlands in northern Kerala, especially during monsoon period.

Another notable observation made during the survey and study (Gopi *et al.*, 2004) was the detection of a habitat site, serving as a natural sanctuary, of the 'Thready Killyfish' (*Horaichthys setnai* Kulkarni), the smallest known fish in India, in the estuarine waters flushing the mangrove vegetation on the mudflat fringe of Thekkumbad Island (Kannur District). A few freshwater species (*in Table-9) were found to have their populations in appreciable abundance during the monsoon season, making use of the freshwater environs of the flood plain system, including the marginal waters-with a very low salinity factor, as low as 0.5 parts per thousand-of the tidal marshes, during the flooding season of monsoon. The juveniles of a large number of species were always available in the shallow waters, often using submerged mangrove-marsh vegetation as shelter. The coastal wetland system of Kannur district has the maximum diversity of species, about 110, out of 122 species, followed by the coastal wetland systems of Kozhikode, Kasaragod and Malappuram showing the diversity and distribution of fish species in their respective lower levels.

Reptilia and Amphibia

The herpetofauna of mangrove ecosytem of northern Kerala comprise of an altogether diversity of species, approximately 14 species (Table-10), which include 13 species of reptilian fauna and a lone species of Amphibia. Among the reptilian fauna, *Lepidochelys olivacea* (Eschscholtz), *Melanochelys trijuga* (Schweigger), *Pelochelys cantorii* (Gray), and *Varanus bengalensis* (Daudin), are endangered species included under the Schedule I of the Wild Life (Protection) Act, 1972.

The remaining species of lizards (3species) and snakes (6 species) are opportunistic terrestrial habitat feeders, which can even be seen in the environs of the homestead biotope in the surroundings close to or away from the Mangrove systems, except exhibiting a skewed preference to the premises in somewhat isolated settings, or locale normally undisturbed by human activity. The lone species of frog *Rana cyanophlyctis* (Schneider) is characteristically the only amphibian species which can withstand the weak salinity factor in the aquatic systems and therefore known to be the only salinity tolerant species that is found having the distribution in the environs of brackish waters having mild salinity content, including mangrove systems flushed by fresh water inflows from the upland areas or rivers.

Certain sandy beach cum mangrove ecosystem areas in northern Kerala, for example, the Kolavipalam beach near Kottapuzha estuary and the closely lying mangrove-lined estuary embayment, in Kozhikode District, have been found to be a prime turtle nesting site of the marine turtle, *Lepidochelys olivacea*, popularly known as Olive Ridley- and, also, listed in Appendix I of CITES. The marine-coastline-estuarine habitats, with the abounding mangrove vegetation around the estuary bay as well with the advantage of being in isolated settings of the ecotone make this interface zone an ideal turtle nesting site (Gopi and Radhakrishnan, 2000). Unfortunately this prime nestling site in Kerala has been facing a grave threat posed by the indiscriminate sand mining as well as the beach-based constructional activities, simultaneously destroying the mangroves through land reclamation processes.

Aves

The avifauna associated with the mangrove-estuarine cum shore beach system is so rich and diverse that each and every conceivable niche of bird habitat(s) is observed with one or other type of a bird, either a migrant or resident species, sometimes singly, or in a small or large flock. They are also as varied as waterfowl, wading birds, rails and shorebirds, birds of prey, and ground and shrub birds. In ecological considerations, therefore birds constitute the most dominant community controlling the trophic levels in food linkages, even one step above fishes, the second dominant community linked to the wetland's ecological systems. The diversity feature of the habitats in varied categories of marsh wetland systems, coupled with the diverse and rich vegetation in both the terrestrial and aquatic environments, inevitably justifies the notion of the coastal wetland systems being well known for their bird diversity and abundance, probably supporting the largest and most diverse populations of birds.

In the coastal belts of North Kerala, the bird diversity found associated with the coastal wetland system, is estimated to be about approximately 196 species (Table-11 & Plate-4). These include both resident and winter migratory birds. However, the numbers and variety of birds vary from one site of occupation or foraging, depending on the availability of their biological requirements like food and physiological and behavioural adjustments.

Large flocks, comprising of many hundreds, or even thousands, of birds, which make seasonal migrations between high-latitude summer habitats and low-latitude wintering grounds, rely on intertidal flats for feeding along the way. They winter their season in the wetlands feeding predominantly on polychaetes and other burrowing worms, crustaceans like shrimps, and small fishes, including the juveniles/fingerlings of the larger fish species; each bird takes many hundreds of shrimps, worms and fishes and accumulates enough fat, adding up to their body weight, before taking off on a nonstop journey. The flock of the year-round resident birds of these wetland areas sustain themselves with their feeding and breeding cycles perpetually continuing here itself, depending on the productive biotic potential of the wetland system.

Mammalia

The mammals closely associated with mangrove-estuarine coastal systems are to depend, for their food and shelter, mainly on this ecosystem in much intimate ways and means. A diversity of mammals feed within the system, occasionally or frequently consuming invertebrates and fish. Otter *Lutrogale perspicillata* feed almost entirely on aquatic resources. One characteristic feature of this amphibious mammal is that they can maintain a viable population, even if their home ground is experiencing considerable human presence, as long as its nest sites (holts), refuges and a good cover of vegetation, etc, are intact. Other predator like *Felis chaus* employ a variety of hunting techniques, despite being morphologically constrained to hunt by wading, diving or swimming. About 13 species of mammals (Table-12) are known to occur in the mangrove environs and in the premises of other wetland types in North Kerala.

CONCLUSION

Among the mangrove systems surveyed in the four districts of northern Kerala, the coastal areas of the Kannur District harboured the best available stocks of the mangrove vegetation, holding the bulk of the area-extent of approximately 3500 hectares, which form about 83 % of the state's mangrove cover. The mangrove vegetation of the Kozhikode District, second in position as regards the mangrove-richness in northern Kerala, was uncomparably much less than the mangrove-richness of the Kannur District, with 200 hectares, i.e., about 5 % of the state's mangrove ecosystem. Both Malappuram and Kasaragod Districts exhibited only sporadic distribution of small patches in the coastal plains, holding about 100 hectares (2.4 %) and 50 hectares (1 %) of the state's mangrove wealth (vide, Table-1; Fig. 1) respectively.

Survey and study of the mangroves and their faunal associates in northern Kerala based on the collections/observations of fauna revealed the presence of altogether 489 species of fauna comprising of both invertebrates and vertebrates. Among the sample collections of specimens made during the surveys, as many as 144 species of invertebrates comprising of 24 species of Arachnida, 11 species of hymenopterans of the Superfamily Chalcidoidea, 23 species of Odonata, 33 species of Lepidoptera (butterflies), 21 species of Mollusca, 7 species of Annelida and 25 species of Crustacea (consisting of crabs and prawns) were identified and inventoried. Among the vertebrate fauna collected/observed (most of them observed ones in the field, like reptiles, birds and mammals, and part of them only collected, like ichthyofauna) indicated the presence or occurrence of 345 species. Among them included 122 species of ichthyofauna, 14 species of Herpetofauna, including a lone amphibian species, 196 species of birds and 13 species of mammals. Faunal analyses reveal that the mangrove wetlands of the Kannur District, owing to their richness of the vegetation stands as well as the diversity of the aquatic habitat environs, harboured richer assemblage of faunal associates. Vertebrate fauna recorded from the mangrove wetlands of the Kannur District showed maximum diversity of avifauna, about179 species, followed by the fish faunal diversity of 112 species (vide, Figs. 4-5), which exemplifies indirectly the potential of the mangrove ecosystem of this district.

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Table-2 : Spider fauna (Arachnida) recorded from the mangroves in Northern Kerala.

Sl. No.	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Class : ARACHNIDA				
	Order : ARANEAE				
	Family : TETRAGNATHIDAE				
1.	*Tetragnatha mandibulata* Walckanaer	+	-	-	+
2.	*Tetragnatha* sp.	+	+	-	+
3.	*Eucta* sp.			+	
	Family : SPARASSIDAE				
4.	*Sparassus* sp.				+
	Family : OXYOPIDAE				
5.	*Oxyopes shwatae* Tikader	-	+	-	+
6.	*Oxyopes* sp.	+	+	+	
	Family : THOMISIDAE				
7.	*Camaricus formosus* Thorel	-	+	-	-
8.	*Thomisus cherapunjeus* Tikader				+
9.	*Thomisus* sp.	+	-	-	-
10.	*Rheme* sp.			+	
11.	*Tibellus* sp.	-	+	-	-
12.	*Borris* sp.	-	+	-	-
13.	*Monaeses* sp.	-	+	-	-
14.	*Runcinia* sp.	+	-	-	-
	Family : ARANCIDAE				
15.	*Gasteracantha geminata* (Fabr.)	-	+	-	-
16.	*Zygeilla melanocrania* (Thorell)	-	-	+	-
17.	*Neoscona rumpfi* (Thorell)	-	+	-	-
18.	*Neoscona bengalensis* Tikader	-	-	+	-
19.	*Leucauge sp.*	-	+	-	-
20.	*Cyrtophora keralicus* sp.nov.	-	-	+	-
21.	*Argiope mangroviala* sp.nov.	-	+	-	-

Sl. No.	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Family : SALTICIDAE				
22.	*Salticus sp.*	+	+	+	-
	Family : CLUBIORIDAE				
23.	*Clubiona* sp.	+	+	+	-
	Family LYCOSIDAE				
24.	*Lycosa sp.*	-	-	+	-

Table- 3 : Chalcidoid fauna (Hymenoptera : Insecta) recorded from the Mangroves in Northern Kerala

Sl. No.	Species	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Order : HYMENOPTERA				
	Suborder : APOCRITA				
	Super family : CHALCIDOIDEA				
	Family : CHALCIDIDAE				
	Subfamily : CHALCIDINAE				
1.	*Brachymeria lasus* (Walker)	-	-	+	-
	Subfamily : HALTICHELLINAE				
2.	*Hockeria atra* Masi	-	+	-	-
	Family: Pteromalidae				
	Subfamily : EUNOTINAE				
3.	*Cephaleta brunneiventris* Motschulsky	-	+	-	-
	Subfamily : PTEROMALINAE				
4.	*Propicroscytus oryzae* (Subba Rao)	-	+	-	-
5.	*Dinarmus maculates* (Masi)	-	+	-	-
6.	*Chlorocytus indicus* Sureshan	-	+	-	-
7.	*Norbanus thekkadiensis* Sureshan	-	-	+	-
	Family : EURYTOMIDAE				
	Subfamily : EURYTOMINAE				
8.	*Eurytoma poroensis* Mukerjee	-	-	+	-
9.	*Eurytoma agalica* Narendran	-	+	-	-
10.	*Plutarchia marginata* Narendran & Padmasenan	-	+	-	-
11.	*Tetramesa* sp.	-	-	+	-

Table-4 : Dragonflies (Odonata : Insecta) recorded from Mangroves in Northern Kerala

Sl. No.	Species	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Order : ODONATA				
	Suborder : ZYGOPTERA				
	Family : COENAGRIONIDAE				
1.	*Aciagrion occidentale* Laidlaw	-	+	-	-
2.	*Agriocnemis pygmaea* (Rambur)	+	+	+	+
3.	*Ceriagrion cerinorubellum* (Brauer)	+	+	+	+
4.	*Ceriagrion coromandelianum* (Fabricius)	+	+	+	+
5.	*Ischnura aurora aurora* (Brauer)	+	+	+	+
6.	*Mortonagrion varralli* Fraser		+		
7.	*Pseudagrion microcephalum* (Rambur)	+	+	+	+
	Suborder : ANISOPTERA				
	Family : LIBELLULIDAE				
8.	*Brachythemis contaminata* (Fabricius)	+	+	+	+
9.	*Crocothemis servilia servilia* (Drury)	+	+	+	+
10.	*Diplacodes trivialis* (Rambur)	+	+	+	+
11.	*Macrodiplax cora* (Brauer)			+	
12.	*Neurothemis tullia tullia* (Drury)	+	+	+	+
13.	*Orthetrum chrysis* Selys	-	+	+	+
14.	*Orthetrum luzonicum* (Brauer)	-	-	+	+
15.	*Orthetrum pruinosum neglectum* (Rambur)			+	
16.	*Orthetrum sabina sabina* (Drury)	+	+	+	+
17.	*Pantala flavescens* (Fabricius)	+	+	+	+
18.	*Rhodothemis rufa* (Rambur)			+	+
19.	*Rhyothemis variegata variegata* (Linnaeus)	+	+	+	+

Sl. No.	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
20.	*Tholymis tillarga* (Fabricius)	+	+	+	+
21.	*Tramaea limbata* (Desjardins)		+	+	
22.	*Trithemis pallidinervis* (Kirby)		+		+
23.	*Urothemis signata signata* (Rambur)	+	+	+	+

Table-5 : Butterflies (Lepidoptera: Rhopalocera : Insecta) recorded from Mangroves in Northern Kerala

Sl. No	Species	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Order : LEPIDOPTERA				
	Suborder : RHOPALOCERA				
	Family : PAPILIONIDAE				
1.	*Pachliopta aristolochiae* (Fabricius)	+	+	-	+
2.	*Pachliopota hector* (Linnaeus)	+	+	+	+
3.	*Papilio polytes* (Linnaeus)	+	+	+	+
4.	*Papiio polymnestor* (Cramer)		+		
5.	*Graphium sarpedon* (Felder & Felder)	-	+	-	-
	Family : PIERIDAE				
6.	*Catopsilia Pomona* (Fabricius)	+	+	+	+
7.	*Catopsilia pyranthe* (Linnaeus)		+		+
8.	*Eurema hecabe* (Linnaeus)	+	+	+	+
9.	*Delias eucharis* (Drury)		+	+	-
10.	*Leptosia nina* (Fabricius)	+	+	+	+
11.	*Cepora nerissa* (Fabricius)	-	+	-	-
	Family : NYMPHALIDAE				
	Subfamily : SATYRINAE				
12.	*Melanitis leda* (Linnaeus)	+	+	+	+
13.	*Elymnias hypermnestra* (Linnaeus)		+		
14.	*Mycalsesis perseus* (Fruhstorfer)	+	+	-	-
15.	*Orsotrioena medus* (Fabricius)	-	+	-	+

Sl. No	Species	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Subfamily : HELICONIINAE				
16.	*Acraea violae* (Fabricius)	-	+	+	-
	Subfamily : NYMPHALINAE				
17.	*Neptis hylas* (Moore)	-	+	+	+
18.	*Euthalia aconthea* (Cramer)	-	+	-	+
19.	*Ariadne merione* (Cramer)		+	+	+
20.	*Junonia almana* (Linnaeus)	+	+	+	+
21.	*Junonia atlites* (Linnaeus)	+	+	+	+
22.	*Hypolimnas misippus* (Linnaeus)	+	+	-	+
	Subfamily : DANAINAE				
23.	*Tirumala limniace* Gmelin	+	+	+	+
24.	*Danaus chrysippus* (Linnaeus)	+	+	+	+
25.	*Euploea core* (Cramer)	+	+	+	+
	Family : LYCAENIDAE				
26.	*Zizula hylax* (Fabricius)		+	+	
27.	*Jamides celeno* (Fabricius)	+	+	+	+
28.	*Curtetis thetis* (Drury)	+	+		
	Family : HESPERIIDAE				
29.	*Hasora chromus* (Cramer)	+	+	+	+
30.	*Suastus gremius* (Fabrcius)	-	+	-	-
31.	*Grangara thyrsis* (Fabricius)	+	+	-	-
32.	*Telicota ancilla* (Moore)	-	+	-	-
33.	*Pelopidas mathias* (Fabricius)	+	+	-	-

Table-6 : Molluscs recorded from Mangrove wetlands in Northern Kerala.

Sl. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Class : GASTROPODA				
	Sub class : PROSOBRANCHIA				
	Order : ARCHEOGASTROPODA				
	Family : GASTROPODA				
1.	*Umbonium vestiarium* (Linnaeus)	-	+	+	+
	Family : NERITIDAE				
2.	*Neritina (Dostia) violacea* Gmelin	+	+	+	+
3.	*Nerita albicilla* Linnaeus	+	+	+	-
4.	*Cithon oulaniensis* (Lesson)		+		
	Family : PILIDAE				
5.	*Pila virens* Lamarck	+	+	+	+
	Order : MESOGASTROPODA				
	Family : LITTORINIDAE				
6.	*Littorina (Littorinopsis) melanotima* Gray	-	+	+	+
7.	*Littorina (Littorinopsis) scabra scabra* (Linnaeus)	+	+	+	+
8.	*Littoraria undulata* (Gray)	+	+		
	Family : POTAMIDIDAE				
9.	*Cerithidea (Cerithideopsilla) cingulata* Gmelin	+	+	+	+
10.	*Telescopium telescopium* (Linnaeus)	+	+	+	+
	Family : THIARIDAE				
11.	*Thiara scabra* (Muller)	+			

Sl. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Order : NEOGASTROPODA				
	Family : NASSARIIDAE				
12.	*Nassarius (Hima) stolatus* (Gmelin)	+	+	-	+
	Family : PLANORBIDAE				
13.	*Indoplanorbis exustus* (Deshayes)	+	+	+	-
	Order : SOLEOLIFERA				
	Family : ONCHIDIDAE				
14.	*Onchidium verruculatum* Cuvier	+	+	-	-
	Class : BIVALVIA				
	Order : ARCOIDA				
	Family : ARCIDAE				
15.	*Anadara granosa* (Linnaeus)	+	+	+	+
	Order : PTERIOIDA				
	Family : OSTREIDAE				
16.	*Cassosterea madraspatensis*	+	+	+	+
17.	*Saccostrea cucullata* (Born)	+	+	+	+
	Order : VENEROIDA				
	Family : VENERIDAE				
18.	*Meretrix casta* (Gmelin)	+	+	-	
19.	*Meretrix meretrix* (Linnaeus)	+	+	+	+
20.	*Paphia malabarica* (Schroeter)	+	+	+	+
21.	*Villorita cyprinoids* (Gray)	+	+	-	-

Table-7: Annelids (Polychaeta) recorded from Mangrove wetlands in Northern Kerala.

Sl. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Family : NEREIDAE				
1	*Namalycastis indica* (Southern)	+	+	+	+
2.	*Tylonereis bogoyawlenskyi* Fauvel	-	+	+	-
3.	*Dendronereis arborifera* Peters	-	+	-	-
4.	*Nereis glandicincta* (Southern)	+	+	-	+
	Family : NEPHTYIDAE				
5.	*Nephtys oligobranchia* Southern	-	-	+	+
	Family: Glyceridae				
6.	*Glycera alba* (Muller)	+	+	-	-
	Family EUNICIDAE				
7.	*Marphysa sanguinea* (Montagu)	-	-	+	-

Table-8 : Crabs and Prawns (Crustacea) recorded from Mangrove wetlands in Northern Kerala.

Sl. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Class : CRUSTACEA				
	Order : DECAPODA				
	Family : CALAPPIDAE				
1.	*Calappa lophos* (Herbst)	+	+	+	+
2.	*Matuta victor* (Fabricius)	-	+	+	+
	Family : PORTUNIDAE				
3.	*Charybdis (Charybdis) feriatus* (Linnaeus)	+	+	+	+
4.	*Charybdis (Goniohellenus) hoplites* (Wood-Mason)	-	+	+	+
5.	*Charybdis (Charybdis) lucifera* (Fabricius)	+	+	+	+
6.	*Charybdis sp.*	-	+	-	-
7.	*Portunus pelagicus* (Linnaeus)	+	+	-	-
8.	*Portunus sanguinolentus* (Herbst)	+	+	+	+
9.	*Scylla serrata* (Forskal)	+	+		
10.	*Scylla tranquebarica* (Fabricius)	+	+	+	+
	Family : MAJIDAE				
11.	*Doclea rissonii* (Leach)	-	+	-	+
	Family : GRAPSIDAE				
12.	*Clistocoeloma merguiense* (De Man)	+	+	+	-

Sl. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
13.	*Metopograpsus latifrons* (White)	-		+	-
14.	*Parasesarma plicatum* (Latreille)	-	+	+	+
15.	*Varuna litterata* (Fabricius)	+	+	+	+
	Family : OCYPODIDAE				
16.	*Dotilla intermedia* De Man	-	+	+	-
17.	*Dotilla myctiroides* (H. Milne-Edwards)	+	+	-	-
18.	*Ocypode ceratophthalma* (Pallas)	-	+	+	+
19.	*Uca lactea* (de Haan)	+	+	+	+
	Family : PILUMNIDAE				
20.	*Neosarmatium malabaricum* (Henderson)				
	Suborder : DENDROBRANCHIATA				
	Family PENAEIDAE				
21	*Metapenaeus dobsoni* (Miers)	+	+	+	+
22.	*Metapenaeus sp.*		+		
23.	*Penaeus monodon* Fbricius	+	+	+	+
24.	*Penaeus indicus* H. Milne Edwards	+	+	+	+
	Suborder : PELOCYEMATA				
	Family : PALAEMONIDAE				
25.	*Macrobrachium rosenbergii* (deMan)	+	+	+	+

Table-9 : Fishes of Mangrove-Estuarine system in Northern Kerala

Sl. No.	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Order : ELOPIFORMES				
	Family : ELOPIDAE				
1.	*Elops machnata* (Forsskal)	+	+	+	-
	Family : MEGALOPIDAE				
2.	*Megalops cyprinoids* (Broussonet)	+	+	+	+
	Order : ANGUILLIFORMES				
	Family : ANGUILLIDAE				
3.	*Anguilla bengalensis bengalensis* (Gray)	+	+	+	+
	Family : MURAENIDAE				
4.	*Lycodontis tile* (Hamilton-Buchanan)	+	+	+	-
5.	*Thyrsoidea macrura* (Bleeker)	-	+	+	-
	Family : OPHICHTHIDAE				
6.	*Lamnostoma orientalis* (McClelland)	+	+	-	
7.	*Pisodonophis boro* (Hamilton-Buchanan)	+	+	+	+
	Family: MURAENESOCIDAE				
8.	*Congersox talabon* (Cuvier)	+	+	-	-
9.	*Congresox talabonoides* (Bleeker)		+	-	-
10.	*Muraenesox bagio* (Ham.-Buch)	+	+	+	-
11.	*Muraenesox cinereus* (Forsskal)	+	+	-	-
	Order : CLUPEIFORMES				
	Family : CLUPEIDAE				

SL. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
12.	*Nematalosa nasus* (Bloch)	+	+	+	-
13.	*Dayella Malabarica* (Day)	+	+		+
14.	*Ethirava fluviatilis* Deraniyagala	+	+	+	+
	Family ENGRAULIDIDAE				
15.	*Stolephorus commersonii* Lacepede	+	+	+	+
16.	*Stolephorus indicus* (van Hasselt)	-	+	+	-
17.	*Thryssa malabarica* (Bloch)	+	+	+	-
	Order GONORHYNCHI-FORMES				
	Family CHANIDAE				
18.	*Chanos chanos* (Forsskal)	-	+	+	-
	Order : CYPRINIFORMES				
	Family : CYPRINIDAE				
19.	*Puntius vittatus* Day*	-	+	+	-
20.	*Rasbora daniconoius* (Ham.-Buch.)*	-	+	+	-
	Order : SILURIFORMES				
	Family : *BAGRIDAE*				
21.	*Horabagrus brachysoma* (Gunther)	-	+	+	-
22.	*Mystus cavasius* (Hamilton-Buchanan)	+	+	-	-
23.	*Mystus gulio* (Hamilton-Buchanan)	+	+	+	+
24.	*Mystus oculatus* (Valenciennes)	-	+	-	+
25.	*Mystus vittatus* (Bloch)	+	+	+	+
	Family : ARIIDAE				

SL No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
26.	*Arius arius* (Hamilton-Buchanan)	+	+	+	+
27.	*Arius caelatus* Valenciennes	-	+	+	
28.	*Arius tenuispinis* Day	+	+	+	+
	Family : PLOTOSIDAE				
29.	*Plotosus canius* Hamilton-Buchanan	+	+	-	-
30.	*Plotosus limbatus* Valenciennes	-	+	+	+
31.	*Plotosus lineatus* (Thunberg)	+	+	+	+
	Order : BATRACHOIDI-FORMES				
	Family : BATRACHOIDIDAE				
32.	*Batrichthys grunniens* (Linnaeus)	+	+	+	+
	Order : MUGILIFORMES				
	Family : MUGILIDAE				
33.	*Liza macrolepis* (Smith)	+	+	-	-
34.	*Liza parsia* (Hamilton-Buchanan)	+	+	+	+
35.	*Liza subviridis* (Valenciennes)	-	+	+	-
36.	*Liza vaigiensis* (Quoy & Gaimard)				+
37.	*Mugil cephalus* Linnaeus	+	+	+	+
38.	*Rhinomugil corsula* (Hamilton-Buchanan)	-	+	-	+
39.	*Valamugil cunnesius* (Valenciennes)	+	-	-	+
	Order : BELONIFORMES				
	Family : ADRIANICHTHYIDAE				
40.	*Horaichthys setnai* Kulkarni	-	+	-	-

SL. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Family : BELONIDAE				
41	*Strongylura strongylura* (van Hasselt)	+	+	+	-
42.	*Xenentodon cancila* (Ham.-Buch)*	-	+	-	+
	Family : HEMIRAMPHIDAE				
42.	*Hyporhamphus limbatus* (Valenciennes)	+	+	+	-
44.	*Hyporhamphus xanthopterus* (Valenciennes)	-	+	-	+
	Order : CYPRINODONTI FORMES				
	Family : APLOCHEILIDAE				
45.	*Aplocheilus blocki* (Arnold)*	+	+	+	+
46.	*Aplocheilus lineatus* (Valenciennes)*	+	+	+	+
	Order : GASTEROSTEIFORMES				
	Family SYNGNATHIDAE	+	+	+	-
47.	*Ichthyocampus carce* (Hamilton-Buchanan)	-	+	+	-
48.	*Microphis brachyurus* (Bleeker)	-	+	-	+
49.	*Microphis cuncalus* (Hamilton-Buchanan)	+	+	+	-
	Order : SYNBRANCHIFORMES				
	Family SYNBRANCHIDAE				
50.	*Ophisternon bengalense* McClelland	+	+	+	-
	Order SCORPAENIFORMES				
	Family PLATYCEPHALIDAE				

SL. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
51.	*Platycephalus cantori* Bleeker	+	+	+	+
52.	*Platycephalus indicus* (Linnaeus)	+	-	+	-
	Order : PERCIFORMES				
	Family : CENTROPOMIDAE				
53.	*Lates calcarifer* (Bloch)	+	+	+	+
	Family : CHANDIDAE				
	(=AMBASSIDAE)				
54.	*Ambassis commersoni* Cuvier	+	+	+	+
55.	*Ambassis dussumieri* Cuvier				+
56.	*Ambassis gymnocephalus* (Lacepede)	+	+	+	-
57.	*Ambassis nalua* (Hamilton-Buchanan)	+	+	+	+
58.	*Chanda nama* (Hamilton-Buchanan)	-	+	+	+
59.	*Parambassis dayi* (Bleeker)	-	+	-	-
	Family : SERRANIDAE				
60.	*Epinephelus areolatus* (Forsskal)	-	+	+	-
61.	*Epinephelus diacanthus* (Valenciennes)	-	+	-	
62.	*Epinephelus flavocaeruleus* (Lacepede)	-	+	-	-
63.	*Epinephelus malabaricus* Schneider	+	+	+	+
64.	*Epinephelus tauvina* (Forsskal)	+	+	+	+
	Family : SILLAGINIDAE				
65.	*Sillago sihama* (Forsskal)	+	+	+	+
66.	*Sillago vincenti* Mc Kay	-	+	-	+

SL No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Family : CARANGIDAE				
67.	*Alepes para* (Cuvier)	+	+	-	+
68.	*Carangoides praeustus* (Bennett)	-	+	+	
69.	*Caranx carangus* (Bloch)	+	+	+	+
70.	*Caranx ignobilis* (Forsskal)	+	+	+	+
71	*Caranx melampygus* Cuvier				
72.	*Caranx sexfasciatus* Quoy & Gaimard	-	+	-	+
	Family : LEIOGNATHIDAE				
73.	*Gazza minuta* (Bloch)	+	+	+	+
74.	*Leiognathus bindus* (Valenciennes)	+	+	+	+
75.	*Leiognathus equulus* (Forsskal)	+	+	+	-
76.	*Leioganthus splendens* (Cuvier)	-	+	+	-
77.	*Secutor insidiator* (Bloch)			+	-
78.	*Secutor ruconius* (Hamilton-Buchanan)	-	+	-	-
	Family : LUTJANIDAE	+	+	+	+
79.	*Lutjanus argentimaculatus* (Forsskal)	+	+	+	+
80.	*Lutjanus johni* (Bloch)	-	+	+	-
	Family : LOBOTIDAE				
81	*Lobotes surinamensis* (Bloch)	-	-	+	-
	Family : GERREIDAE				
82.	*Gerreomorpha setifer* (Hamilton-Buchanan)	+	+	-	-
83.	*Gerres abbreviatus* Bleeker	+	+	-	-

SL. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
84.	*Gerres filamentosus* Cuvier	+	+	+	+
	Family : POLYNEMIDAE				
85.	*Eleutheronema tetradactylum* (Shaw)	-	-	+	+
86.	*Polydactylus indicus* (Shaw)	-	+	-	+
87.	*Polydactylus sextarius* (Bloch)	+	+	-	-
	Family : SCIAENIDAE				
88.	*Daysciaena albida* (Cuvier)	+	+	-	-
89.	*Johnius belangerii* (Cuvier)	-	+.	+	-
90.	*Johnius carouna* (Cuvier)	+	-	-	+
91.	*Johnius carutta* Bloch	+	+	-	-
92.	*Protonibea diacanthus* (Lacepede)	+	+	+	-
	Family : NANDIDAE				
93.	*Nandus nandus* (Hamilton-Buchanan)	+	+	+	+
	Family : CICHLIDAE				
94.	*Etroplus maculatus* (Bloch)	+	+	+	-
95.	*Etroplus suratensis* (Bloch)	+	+	+	+
96.	*Oreochromis mossambica* (Peters)	+	+	+	+
	Family : POMACENTRIDAE				
97.	*Abudefduf sordidus* (Forsskal)	-	+	+	-
98.	*Abudefduf saxatilis* (Linnaeus)	-	+	+	-
99.	*Abudefduf septemfasciatus* C & Val.	-	-	+	+
	Family : TERAPONIDAE				
100.	*Terapon jarbua* (Forsskal)	+	+	+	+
101.	*Terapon puta* Cuvier	-	+	+	-

Sl. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
102.	*Terapon theraps* (Cuvier)	+	+	-	+
	Family : SPHYRAENIDAE				
103.	*Sphyraena jello* Cuvier	-	+	+	-
	Family GOBIIDAE				
104.	*Awaous gutum* (Hamilton-Buchanan)	+	+	+	+
105.	*Glossogobius giuris* (Hamilton-Buchanan)	+	+	+	+
106.	*Oligolepis acutipennis* (Valenciennes)	+	+	-	-
107.	*Stenogobius gymnopomus* (Bleeker)	+	-	+	-
108.	*Parapocryptes rictuosus* (Valenciennes)	+	-	+	-
109.	*Pseuapocryptes lanceolatus* (Bloch & Schneider)	+	-	+	-
110.	*Sicyopterus griseus* (Day)	-	+	+	+
	Family : ELEOTRIDIDAE				
111.	*Butis butis* (Hamilton-Buchanan)	+	+	+	+
112.	*Eleotris fusca* (Schneider)	+	+	+	-
	Family : GOBIOIDIDAE				
113.	*Odontamblyopus rubicundus* (Hamilton-Buchanan)	+	-	+	-
114.	*Taenioides anguillaris* (Linnaeus)	-	+	+	-
	Family : TRYPAUCHENIDAE				
115.	*Trypauchen vagina* (Bloch & Schneider)	+	+	+	+
	Family SCATOPHAGIDAE				
116.	*Scatophagus argus* (Linnaeus)	+	+	+	+

Sl. No.	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Family : ANABANTIDAE	+	+	+	-
117.	*Anabas testudineus* (Bloch)*	-	+	+	-
	Family : BELONTIIDAE				
118.	*Pseudosphromenus cupanus* (Valenciennes)	-	+	+	-
	Order : PLEURONECTI-FORMES				
	Family : CYNOGLOSSIDAE				
119.	*Cynoglossus macrostomus* Norman	+	+	+	-
	Family : SOLEIDAE				
120.	*Euryglossa orientalis* (Bloch & Schneider)	+	+	+	+
	Order : TETRAODONTI-FORMES				
	Family : TETRAODONTIDAE				
121.	*Chelonodon fluviatilis* (Hamilton-Buchanan)	+	+	+	+
122.	*Tetraodon travancoricus* Hora & Nair*	-	-	+	-

* Freshwater species in very low saline waters

Table-10 : Herpetofauna (Reptilia & Amphibia) recorded from Mangrove wetlands in Northern Kerala

Sl. No.	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Class REPTILIA				
	Order TESTUDINES				
	Family : CHELONIDAE				
1.	*Lepidochelys olivacea* (Eschscholtz)	-	-	+	-
	Family : EMYDIDAE				
2.	*Melanochelys trijuga* (Schweigger)	+	+	+	+
	Family : TESTUDINIDAE				
3.	*Pelochelys cantorii* (Gray)	-	+	-	-
	Order SQUAMATA				
	Suborder SAURIA				
	Family : GEKKONIDAE				
4.	*Hemidactylus* sp.	-	+	-	-
	Family : AGAMIDAE				
5.	*Calotes versicolor* (Daudin)	+	+	+	+
	Family SCINCIDAE				
6.	*Mabuya carinata* (Schneider)	+	+	+	+
	Family VARANIDAE				
7.	*Varanus bengalensis* (Daudin)	-	-	+	-
	Suborder SERPENTES				
	Family : COLUBRIDAE				
8.	*Coluber mucosus* (Linnaeus)	-	+	-	-
9.	*Xenochrophis piscator*	+	+	+	+
10.	*Ahaetulla nasuta* (Lacepede)	-	+	-	-
11.	*Cerberus rhynchops* (Schneider)	+	+	-	-

Sl. No.	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Family : ELAPIDAE				
12.	*Naja naja naja* (Linnaeus)	-	+	-	-
	Family : VIPERIDAE				
13.	*Vipera russelli* (Shaw)	-	+	-	-
	Class : AMPHIBIA				
	Order ANURA				
	Family : RANIDAE				
14.	*Rana cyanophlyctis* (Schneider)	+	+	+	+

Table-11 : Avifauna recorded from the Mangrove wetlands in Northern Kerala

Sl. No	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Order : PODICIPIDIFORMES					
	Family PODICIPIDIDAE					
1	Little Grebe	*Podiceps ruficollis*	-	+	+	+
	Order PELICANIFORMES					
	Family PELECANIDAE					
2.	Masked Booby	*Sula dactylatra*	+	+	-	-
	Family : PHALACROCORA-CIDAE					
3.	Indian Shag	*Phalacrocorax fuscicollis*	-	+	-	-
4.	Little Cormorant	*Phalacrocorax niger*	+	+	+	+
	Family : FREGATIDAE		-	-	-	-
5.	Lesser Frigate Bird	*Fregata minor*	-	+	+	-
	Order CICONIIFORMES					
	Family ARDEIDAE					
6.	Grey Heron	*Ardea cinerea*	+	+	+	+
7	Purple Heron	*Ardea purpurea*	+	+	+	+
8.	Little Green Heron	*Ardeola striatus*	+	+	+	+
9.	Pond Heron	*Ardeola grayii*	+	+	+	+
10.	Cattle Egret	*Bubulcus ibis*	+	+	+	+

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
11.	Large Egret	*Ardea alba*	+	+	+	+
12.	Smaller Egret	*Egretta intermedia*	+	+	+	+
13.	Little Egret	*Egretta garzetta*	+	+	+	+
14.	Indian Reef Heron	*Egretta gularis*	+	+	+	+
15.	Night Heron	*Nycticorax nycticorax*	+	+	+	+
16.	Tiger Bittern	*Gorsachius melanolophus*	-	+	+	-
17.	Chestnut Bittern	*Ixobrychus cinnamomeus*	+	+	+	+
18.	Yellow Bittern	*Ixobrychus sinensis*	+	+	+	+
19.	Black Bittern	*Ixobrychus flavicollis*	+	+	+	+
	Family : CICONIIDAE					
20.	Painted Stork	*Mycteria leucocephala*	-	-	-	-
21.	Openbill Stork	*Anastomus oscitans*	-	+	+	+
22.	Whitenecked Stork	*Ciconia episcopus*	+	+	+	+
23.	White Stork	*Ciconia ciconia*	-	+	-	-
	Family : THRESKIORNITHIDAE					
24.	White Ibis	*Threskiornis aethiopica*	-	+	+	+
25.	Glossy Ibis	*Plegadis falcinellus*	-	+	+	-
26.	Black Ibis	*Psuedibis papilosa*	-	+	-	-
27.	Spoonbill	*Platalea leucorodia*	-	+	-	-
	Order : ANSERIFORMES					

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Family : ANATIDAE					
28.	Lesser Whistling Teal	*Dendrocygna javanica*	+	+	+	+
29.	Pintail	*Anas acuta*	+	+	+	-
30.	Common Teal	*Anas crecca*	-	-	+	-
31.	Spotbilled Duck	*Anas poecilorhyncha*	-	+	-	-
32.	Garganey	*Anas querquedula*	+	+	+	+
33.	White-eyed Pochard	*Aythya nyroca*	+	-	-	-
34.	Cotton Teal	*Nettapus coromandelianus*	-	+	-	+
	Order FALCONIFORMES					
	Family : ACCIPITRIDAE					
35.	Blackwinged Kite	*Elanus caeruleus*	+	+	+	-
36.	Honey Buzzard	*Pernis ptilorhyncus*	+	-	-	-
37.	Pariah Kite	*Milvus migrans*	+	+	+	+
38.	Brahminy Kite	*Haliastur indus*	+	+	+	+
39.	Shikra	*Accipiter badius*	+	+	+	+
40.	Crested Hawk- Eagle	*Spizaetus cirrhatus*	+	-	-	-
41.	Whitebellied Sea Eagle	*Haliaeetus leucogaster*	+	+	+	+
42.	Booted Eagle	*Hieraaetus pennatus*		+	-	+
43.	Greater Spotted Eagle	*Aquila clanga*	+	+		+
44.	Pale Harrier	*Circus macrourus*	-	+	-	-

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
45.	Marsh Harrier	*Circus aeruginosus*	+	+	+	+
46.	Crested Serpent Eagle	*Spilornis cheela*	-	+	-	-
47.	Osprey	*Pandion haliaetus*	+	+	+	+
	Family : FALCONIDAE		-	-	-	-
48.	Peregrine Falcon	*Falco peregrinus*	-	+	-	-
	Order : GALLIFORMES					
	Family : PHASIANIDAE					
49.	Red Spurfowl	*Galloperdix spadicea*	+	+	-	-
50.	Grey Junglefowl	*Gallus sonneratii*	-	+	-	-
	Order : GRUIIFORMES					
	Family : RALLIDAE					
51.	Bluebreasted Banded Rail	*Rallus striatus*	+	+	+	+
52.	Banded Crake	*Rallina eurizonoides*	-	+	-	-
53.	Baillon's Crake	*Porzana pusilla*	-	+	+	-
54.	Ruddy Crake	*Porzana fusca*	+	+	+	-
55.	Whitebreasted Waterhen	*Amaurornis phoenicurus*	+	+	+	+
56.	Water Cock	*Galicrex cinerea*	+	+	-	-
57.	Moorhen	*Gallinula chloropus*	-	+	-	-
58.	Purple Moorhen	*Porphyrio porphyrio*	+	+	+	+
59.	Coot	*Fulica atra*	+	+	+	-

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Order : CHARADRIIFORMES					
	Family : JACANIDAE					
60.	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	-	+	-	+
61.	Bronzewinged Jacana	*Metopidius indicus*	+	+	+	+
	Family : HAEMATOPODIDAE					
62.	Oystercatcher	*Haematopus ostralegus*	-	+	+	+
	Family : ROSTRATULIDAE					
63.	Painted Snipe	*Rostratula benghalensis*	-	+	+	+
	Family : RECURVIROSTRIDAE					
64.	Blackwinged Stilt	*Himantopus himantopus*	+	+	+	+
65.	Avocet	*Recurvirostra avosetta*	-	+	+	+
	Family : DROMADIDAE					
66.	Crab Plover	*Dromas ardeola*	+	-	-	-
	Family : GLAREOLIDAE					
67.	Oriental Pratincole	*Glareola maldivarum*	-	+	+	-
68.	Small Indian Pratincole	*Glareola lactea*	+	+	+	+
	Family : CHARADRIIDAE					
69.	Redwattled Lapwing	*Vanellus indicus*	+	+	+	+
70.	Grey Plover	*Pluvialis squatarola*	+	+	+	+
71.	Pacific Golden Plover	*Pluvialis fulva*	+	+	+	+

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
72.	Large Sand Plover	*Charadrius leschenaultii*	+	+	+	-
73.	Ringed Plover	*Charadrius hiaticula*	+	+	-	-
74.	Little Ringed Plover	*Charadrius dubius curonicus*	+	+	+	+
75.	Indian Little Ringed Plover	*Charadrius dubius jerdoni*	+	+	+	+
76.	Kentish Plover	*Charadrius alexandrinus*	+	+	+	+
77.	Lesser Sand Plover	*Charadrius mongolus*	+	+	+	+
78.	Whimbrel	*Numenius phaeopus*	+	+	+	+
79.	Curlew	*Numenius arquata*	+	+	+	+
80.	Blacktailed Godwit	*Limosa limosa*	-	+	+	+
81.	Bartailed Godwit	*Limosa lapponica*	+	+	+	+
82.	Red Shank	*Tringa totanus*	+	+	+	+
83.	Marsh Sandpiper	*Tringa stagnatilis*	+	+	+	+
84.	Greenshank	*Tringa nebularia*	+	+	+	+
85.	Green Sandpiper	*Tringa ochropus*	+	+	+	+
86.	Wood Sandpiper	*Tringa glareola*	+	+	+	+
87.	Terek Sandpiper	*Tringa terek*	+	+	+	+
88.	Common Sandpiper	*Tringa hypoleucos*	+	+	+	+
89.	Turnstone	*Arenaria interpres*	+	+	+	+
90.	Pintail Snipe	*Gallinago stenura*	+	+	+	+
91.	Fantail Snipe	*Gallinago gallinago*	+	+	+	+

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
92.	Jack Snipe	*Gallinago minima*	-	+	+	-
93.	Eastern Knot	*Calidris tenuirostris*	-	+	+	+
94.	Sanderling	*Calidris alba*	+	+	+	+
95.	Little Stint	*Calidris minuta*	+	+	+	+
96.	Temminck's Stint	*Calidris temminckii*	-	+	+	+
97.	Dunlin	*Calidris alpina*	-	+	+	+
98.	Curlew Sandpiper	*Calidris testacea*	+	+	+	+
99.	Broadbilled Sandpiper	*Limicola falcinelus*	+	+	+	+
	Family : LARIDAE					
100.	Herring Gull	*Larus argentatus*	+	+	+	+
101.	Great Blackheaded Gull	*Larus icthyaetus*	+	+	+	+
102.	Brownheaded Gull	*Larus brunnicephalus*	+	+	+	+
103.	Blackheaded Gull	*Larus ridibundus*	+	+	+	+
104.	Whiskered Tern	*Chlidonias hybrida*	+	+	+	+
105.	Gullbilled Tern	*Geochelidon nilotica*	+	+	+	+
106.	Caspian Tern	*Hydroprogne caspia*	+	+	+	+
107.	Indian River Tern	*Sterna aurantia*	-	+	+	+
108.	Common Tern	*Sterna hirundo*	+	+	+	+
109.	Sooty Tern	*Sterna fuscata*	-	+	-	+
110.	Little Tern	*Sterna albifrons*	+	+	+	+

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
111.	Large Crested Tern	*Sterna bergii*	+	+	+	+
112.	Indian Lesser Crested Tern	*Sterna benghalensis*	+	+	+	+
113.	Sandwich Tern	*Sterna sandvicensis*	+	+	+	+
	Order : COLUMBIFORMES					
	Family : COLUMBIDAE					
114.	Yelowlegged Green Pigeon	*Treron phoenicoptera*	+	-	-	-
115.	Blue Rock Pigeon	*Columba livia*	+	+	+	+
116.	Spotted dove	*Streptopelia chinensis*	+	+	+	+
117.	Emerald Dove	*Chalcophaps indica*	+	-	-	-
	Order : PSITTACIFORMES					
118.	Roseringed Parakeet	*Psittacula krameri*	+	+	+	+
119.	Blossomheaded Parakeet	*Psittacula cyanocephala*	+	+	+	+
120	Lorikeet	*Loriculus vernalis*	+	+	+	+
	Order : CUCULIFORMES					
	Family : CUCULIDAE					
121	Pied Crested Cuckoo	*Clamator jacobinus*	-	+	-	-
122	Koel	*Eudynamys scolopacea*	+	+	+	+
123	Crow Pheasant	*Centropus sinensis*	+	+	+	+
	Order : STRIGIFORMES					
	Family : STRIGIDAE					

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
124.	Barn Owl	*Tyto alba*	-	+	-	-
125.	Spotted Owlet	*Athene brama*	+	+	+	-
	Order : APODIFORMES					
	Family : APODIDAE					
126.	Alpine Swift	*Apus melba*	+	+	+	+
127.	House Swift	*Apus affinis*	+	+	+	+
128.	Palm Swift	*Cypsiurus parvus*	+	+	+	+
	Order : CORACIIFORMES					
	Family : ALCEDINIDAE					
129.	Lesser Pied Kingfisher	*Ceryle rudis*	+	+	+	+
130.	Common Kingfisher	*Alcedo atthis*	+	+	+	+
131.	Threetoed Kingfisher	*Ceyx erithacus*	+	-	-	-
132.	Storkbilled Kingfisher	*Pelargopsis capensis*	+	+	+	+
133.	Whitebreasted Kingfisher	*Halcyon smyrnensis*	+	+	+	+
134.	Blackcapped Kingfisher	*Halcyon pileata*	+	+	+	-
	Family : MEROPIDAE					
135.	Bluetailed Bee-eater	*Merops philippinus*	+	+	+	+
136.	Small Green Bee-eater	*Merops orientalis*	+	+	+	+
	Family : CORACIIDAE					
137.	Indian Roller	*Coracias benghalensis*	+	+	+	+

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Order : PICIFORMES					
	Family : CAPITONIDAE					
138	Small Green Barbet	*Megalaima viridis*	+	+	+	-
139	Crimsonthroated Barbet	*Megalaima rubricapilla*	-	+	-	-
	Family : PICIDAE					
140	Goldenbacked Woodpecker	*Dinopium benghalense*	+	+	+	-
	Order : PASSERIFORMES					
	Family : ALAUDIDAE					
141	Bush Lark	*Mirafra assamica*	-	+	+	-
142	Ashycrowned Finch-Lark	*Eremopterix grisea*	+	+	-	-
143	Short-Toed Lark	*Calandrella cinerea*	-	+	-	-
144	Malabar Crested Lark	*Galerida malabarica*	-	+	-	+
145	Eastern Skylark	*Alauda gulgula*	+	+	-	-
	Family : HIRUNDINIDAE					
146	Plain Sand Martin	*Riparia paludicola*	-	+	-	-
147	Eastern Swallow	*Hirundo rustica*	+	+	+	+
148	Wiretailed Swallow	*Hirundo smithii*	+	+	+	+
149	Redrumped Swallow	*Hirundo daurica*	+	+	+	+
	Family : LANIIDAE					
150	Baybacked Shrike	*Lanius vittatus*	-	+	+	-

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
151.	Rufousbacked Shrike	*Lanius schach*	+	+	+	+
152.	Brown Shrike	*Lanius cristatus*	+	+	+	+
	Family : ORIOLIDAE					
153.	Golden Oriole	*Oriolus oriolus*	-	+	+	+
154.	Blackheaded Oriole	*Oriolus xanthornus*	-	-	-	+
	Family : DICRURIDAE					
155.	Black Drongo	*Dicrurus adsimilis*	+	+	+	+
156.	Grey Drongo	*Dicrurus leucophaeus*	+	+	+	+
157.	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	+	+	-	-
	Family : ARTAMIDAE					
158.	Ashy Swalow Shrike	*Artamus fuscus*	+	+	+	+
	Family : STURNIDAE					
159.	Greyheaded Myna	*Sturnus malabaricus*	-	+	-	-
160.	Common Myna	*Acridotheres tristis*	+	+	+	+
	Family : CORVIDAE					
161.	Indian Tree Pie	*Dendrocitta vagabunda*	+	+	+	+
162.	House Crow	*Corvus splendens*	+	+	+	+
163.	Jungle Crow	*Corvus macrorhynchos*	+	+	+	+
	Family : IRENIDAE					
164.	Common Iora	*Aegithina tiphia*	+	+	-	-

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Family : PYCNONOTIDAE					
165	Redwhiskered Bulbul	*Pycnonotus jocosus*	+	+	+	+
	Family : MUSCICAPIDAE					
166	Jungle Babbler	*Turdoides striatus*	+	+	+	+
167	Streaked Fantail Warbler	*Cisticola juncidis*	+	+	+	+
168	Franklin's Wren Warbler	*Prinia hodgsonii*	+	+	+	+
169	Plain Wren Warbler	*Prinia subflava*	+	+	+	+
170	Ashy Wren Warbler	*Prinia socialis*	+	+	+	+
171	Tailor Bird	*Orthotomus sutorius*	+	+	+	+
172	Indian Great Reed Warbler	*Acrocephalus stentoreus*	+	+	+	+
173	Blyth's Reed Warbler	*Acrocephalus dumetorum*	+	+	+	+
174	Leaf Warbler	*Phylloscopus trochiloides*	+	+	+	+
175	Magpie Robin	*Copsychus saularis*	+	+	+	+
176	Stone Chat	*Saxicola torquata*	+	+	-	-
	Family : MOTACILLIDAE					
177	Paddyfield Pipit	*Anthus rutulus*	+	+	+	+
178	Rechard's Pipit	*Anthus richardi*	-	+	-	-
179	Yellow Wagtail	*Motacilla flava*	+	-	-	-
180	Yellowheaded Wagtail	*Motacilla citreola*	+	-	-	-
181	Grey Wagtail	*Motacilla cinerea*	+	+	+	+

Sl. No.	Order/Family/Species	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
182.	White Wagtail	*Motacilla alba*	+	-	-	-
183.	Large Pied Wgtail	*Motacilla maderaspatensis*	+	+	+	+
	Family : DICAEIDAE					
184.	Thickbilled Flowerpecker	*Dicaeum agile*	-	+	+	-
185.	Tickell's Flowerpecker	*Dicaeum erythrorhynchos*	-	+	+	-
	Family : NECTARINIIDAE					
186.	Purplerumped Sunbird	*Nectarinia zeylonica*	+	+	+	+
187.	Loten's Sunbird	*Nectarinia lotenia*	+	+	-	-
188.	Purple Sunbird	*Nectarinia asiatica*	+	+	+	+
	Family : PLOCEIDAE					
189.	House Sparrow	*Passer domesticus*	+	+	+	+
190.	Yellowthroated Sparrow	*Petronia xanthocollis*	+	+	-	+
191.	Baya	*Ploceus philippinus*	+	+	-	-
192.	Streaked Weaver Bird	*Ploceus manyar*	+	+	+	+
193.	Whitebacked Munia	*Lonchura striata*	+	+	+	+
194.	Spotted Munia	*Lonchura punctulata*	+	+	+	+
195.	Whitethroated munia	*Lonchura malabarica*	+	+	+	+
196.	Blackheaded Munia	*Lonchura malacca*	+	+	+	+

Table-12 : Mammals associated with Mangrove wetlands in North Kerala

Sl. No	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Class : MAMMALIA				
	Order : CHIROPTERA				
	Family : PTEROPODIDAE				
1.	*Cynopterus sphinx* (Vahl)	-	+	-	-
2.	*Pteropus giganteus* (Brunnich)	-	+	-	-
	Family : VESPERTILIONIDAE				
3.	*Pipestrellus ceylonicus* (Kelaart)	+	+	-	-
	Order : CARNIVORA				
	Family : CANIDAE				
4.	*Canis aureus* Linnaues	+	+	+	+
	Family : MUSTELLIDAE				
5.	*Lutrogale perspicillata* I. Geoffroy	+	+	+	+
	Family : HERPESTIDAE				
6.	*Herpestes edwardsii* (Geoffroy)	+	+	+	+
	Family : FELIDAE				
7.	*Felis chaus* Guldenstaedt	+	+	+	
8.	*Prionailurus viverrinus* (Bennett)		+		
	Order : RODENTIA				
	Family : SCIURIDAE				
9.	*Funambulus palmarum* (Linnaeus)	+	+	+	+
	Family : MURIDAE				
10.	*Bandicota bengalensis* (Gray)	+	+	+	+
11.	*Bandicota indica* (Bechstein)	+	+	+	+
12.	*Rattus rattus* (Linnaeus)	+	+	+	+
13.	*Mus booduga* (Gray)	-	+	+	-

Table.13 : Mangrove flora of northern Kerala.

Sl. No.	Family/ Plant species	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
	Family : RHIZOPHORACEAE				
1.	*Rhizophora mucronata*	+	+	+	+
2.	*Rhizophora apiculata*	+	+	+	+
3.	*Bruguiera cylindrical*	+	+	+	+
4.	*Bruguiera sexangula*	-	+	-	-
5.	*Kandelia candel*	+	+	+	+
	Family : AVICENNIACEAE				
6.	*Avicennia officinalis*	+	+	+	+
7.	*Avicennia marina*	+	+	+	+
8.	*Avicennia alba*	-	+	-	-
	Family : SONNERATIACEAE				
9.	*Sonneratia caseolaris*	+	+	+	-
10.	*Sonneratia alba*	-	+	+	-
	Family : COMBRETACEAE				
11.	*Luminitzera racemosa*	-	+	-	-
	Family : MYRSINACEAE				
12.	*Aegiceras corniculatum*	+	+	+	+
13.	*Ardisia littoralis*	-	+	-	-
	Family : EUPHORBIACEAE				
14.	*Excoecaria agallocha*	+	+	+	+
	Family BARRINGTONIACEAE				
15.	*Barringtonia racemosa*	+	+	-	-
	Family : ACANTHACEAE				
16.	*Acanthus ilicifolius*	+	+	+	+
	Family : PTERIDACEAE				

Sl. No.	Scientific Name	Kasaragod District	Kannur District	Kozhikode District	Malappuram District
17.	*Acrostichum aureum*	+	+	+	+
	Family : FABACECAE				
18.	*Derris trifoliata*	+	+	+	+
19.	*Derris scandens*	+	+	+	-
	Family : CAESALPINACEAE				
20.	*Caesalpinia nuga*	+	+	+	+
	Family : BIGNONIACEAE				
21.	*Dolichandrone spathaceae*	+	+	+	+
	Family : VERBENACEAE				
22.	*Clerodendron inerme*	+	+	+	+
23.	*Premna serratifolia*	+	+	+	+
	Family : RUBIACEAE				
24.	*Morinda citrifolia*	+	+	+	+
	Family : PANACEA				
25.	*Pandanus tectorius*	+	+	+	+
	Family : MALVACEAE				
26.	*Hibiscus tiliaceous*	-	+	-	-
27.	*Thespesia populnea*	+	+	+	+
	Family : CONVOLVULACEAE				
28.	*Ipomoea companulata*	+	+	+	+
29.	*Ipomoea pes-caprae*	+	+	+	+
	Family : AMARYLLIDACEAE				
30.	*Crinum défixum*	+	+	+	+
	Family : APOCYNACEAE				
31.	*Cerbera manghas*	+	+	+	+

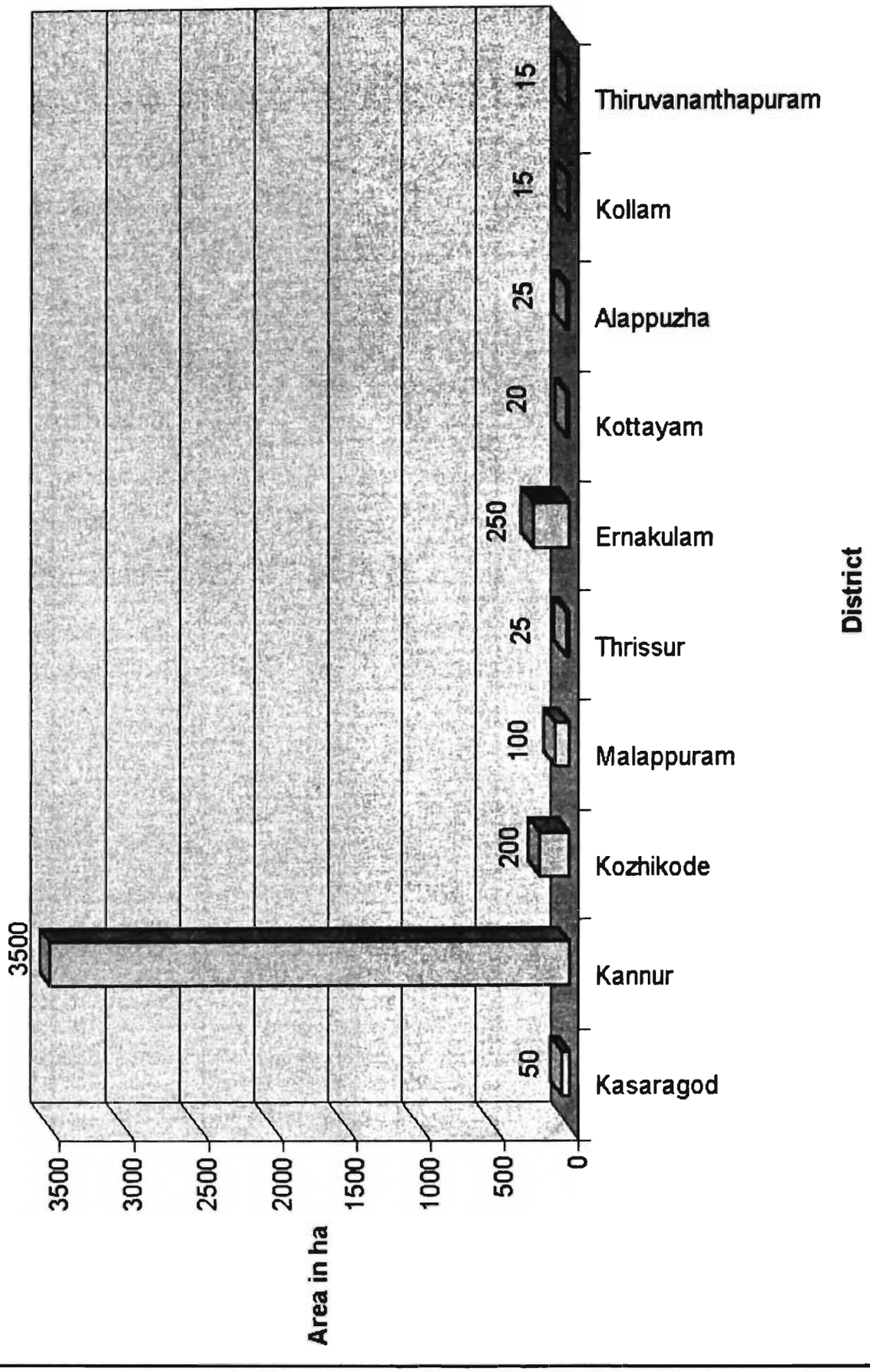


Fig. 1: Extent of mangroves in various districts of Kerala.

Fig. 2. Faunal composition of Invertebrates recorded from mangrove wetlands in Northern Kerala.

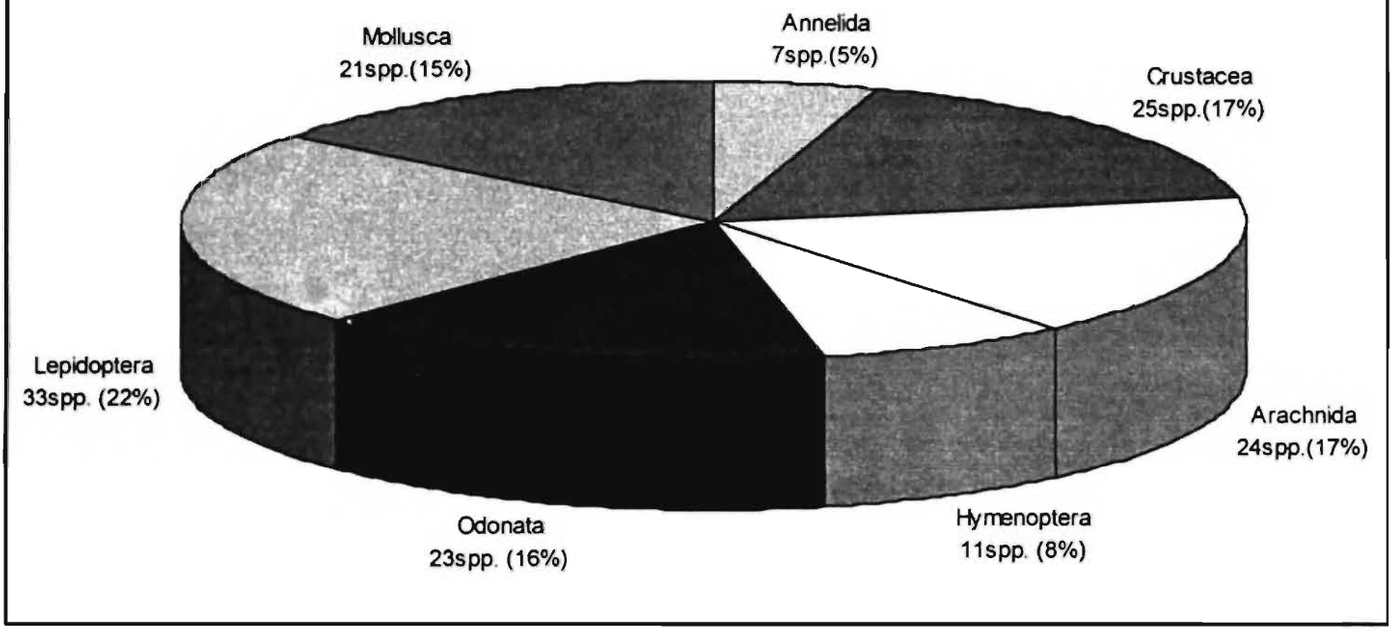
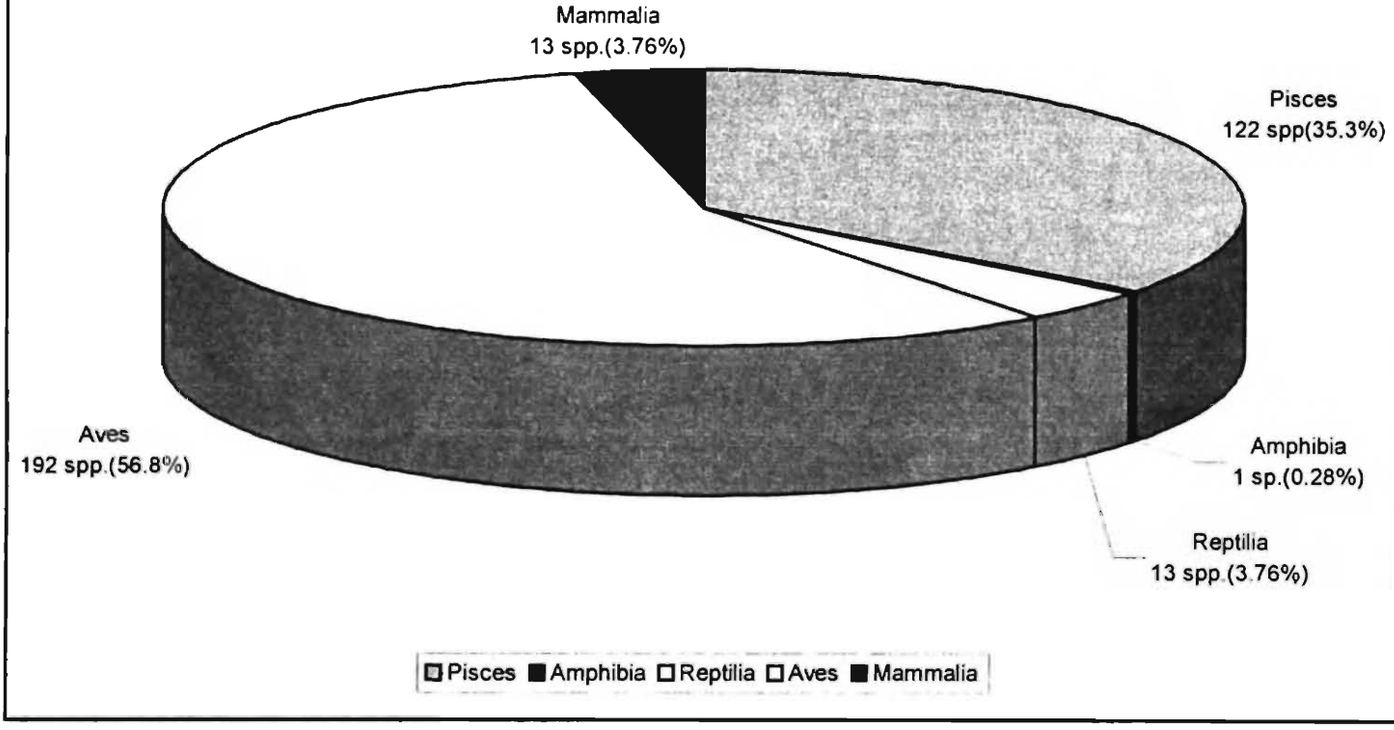
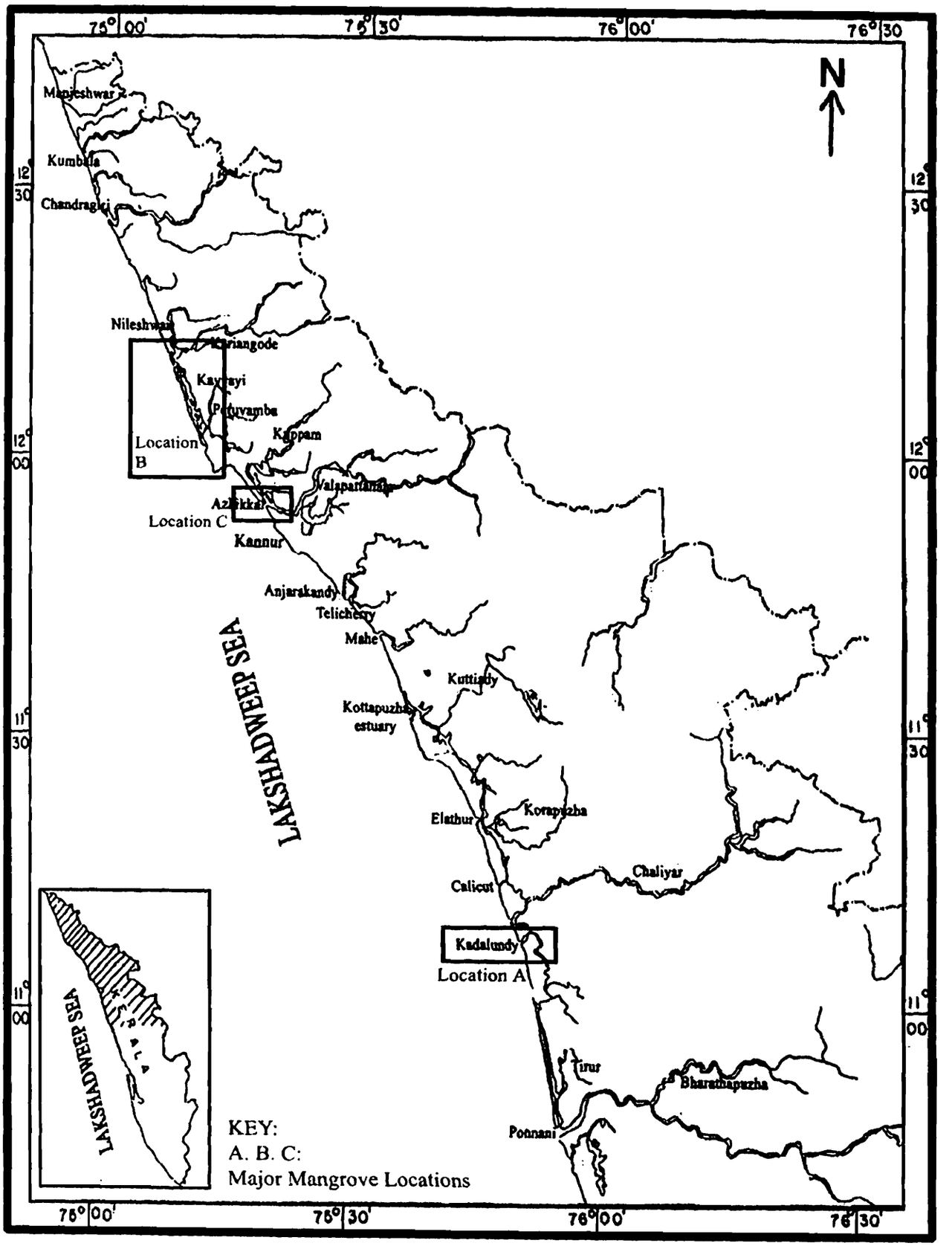


Fig. 3.: Percentage composition of vertebrate fauna recorded from the Mangrove wetlands in Northern Kerala.

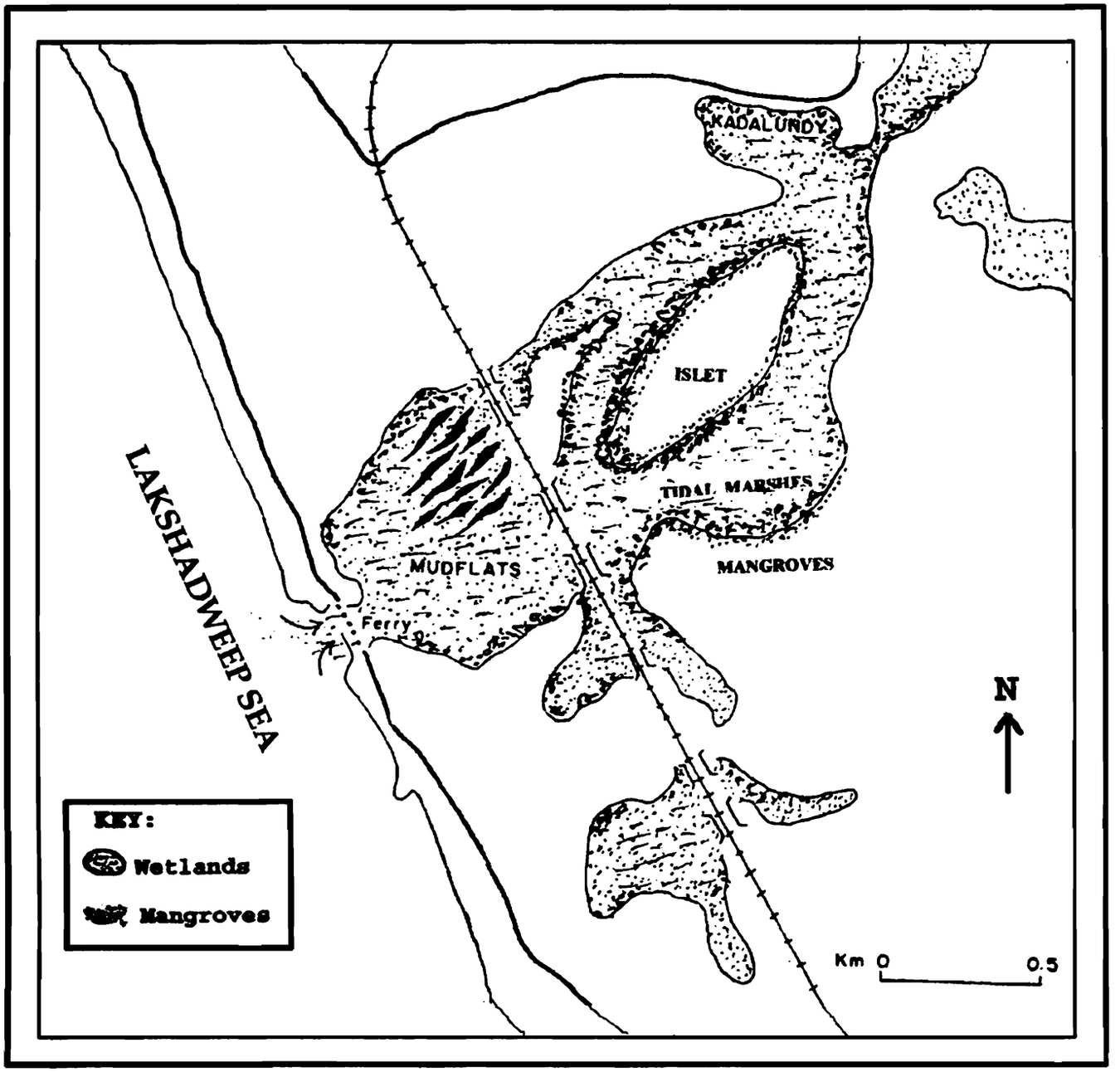


MAP - 1

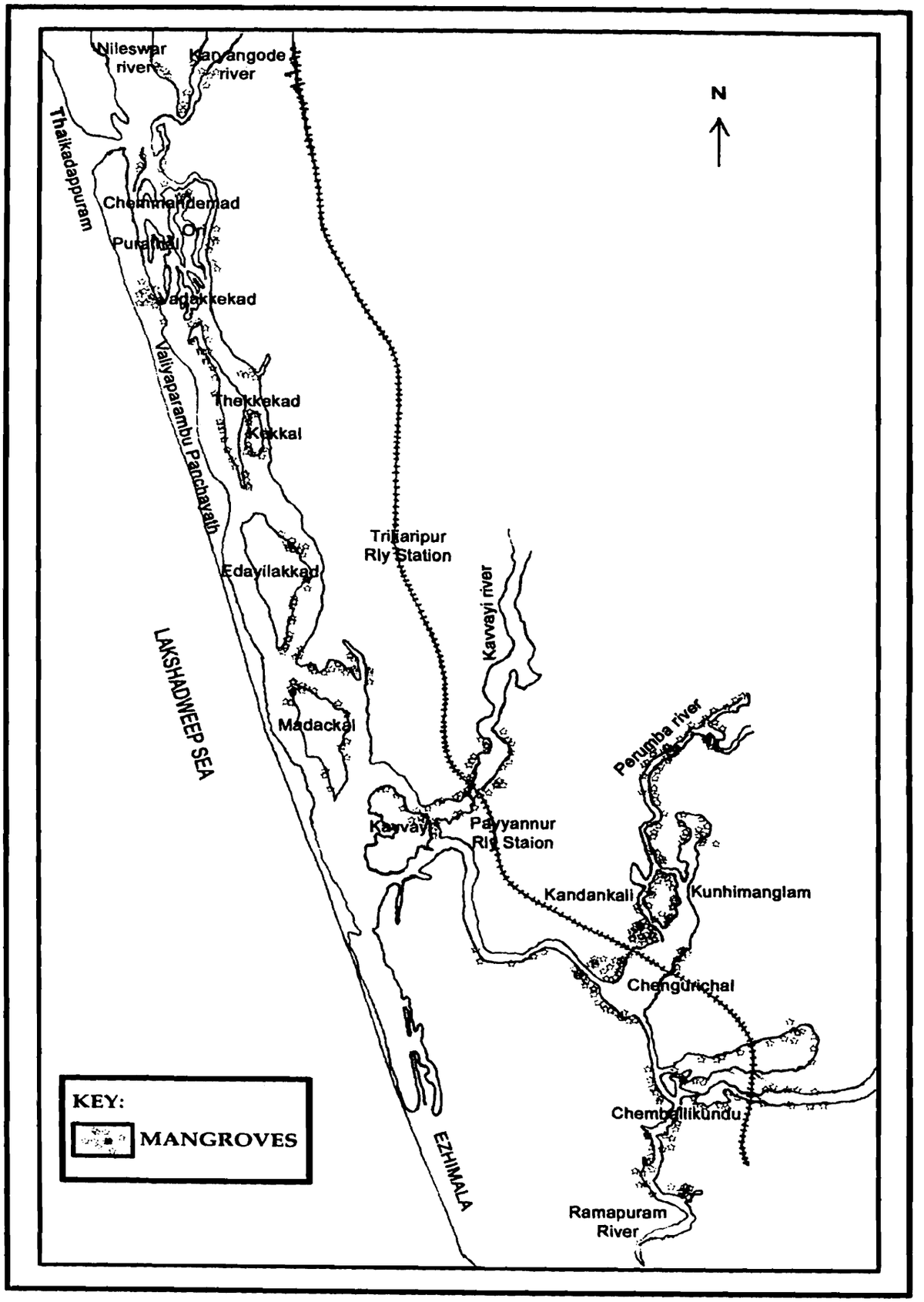
STUDY AREA : NORTHERN KERALA



MAP - 1A : Mangroves of Kadalundy Wetlands
(Mangrove Location : A)



MAP - 1B : Mangroves of Ezhimala-Kavvayi Complex
(Mangrove Location : B)



MAP - 1C : Mangroves of Madakkara
(Mangrove Location : C)

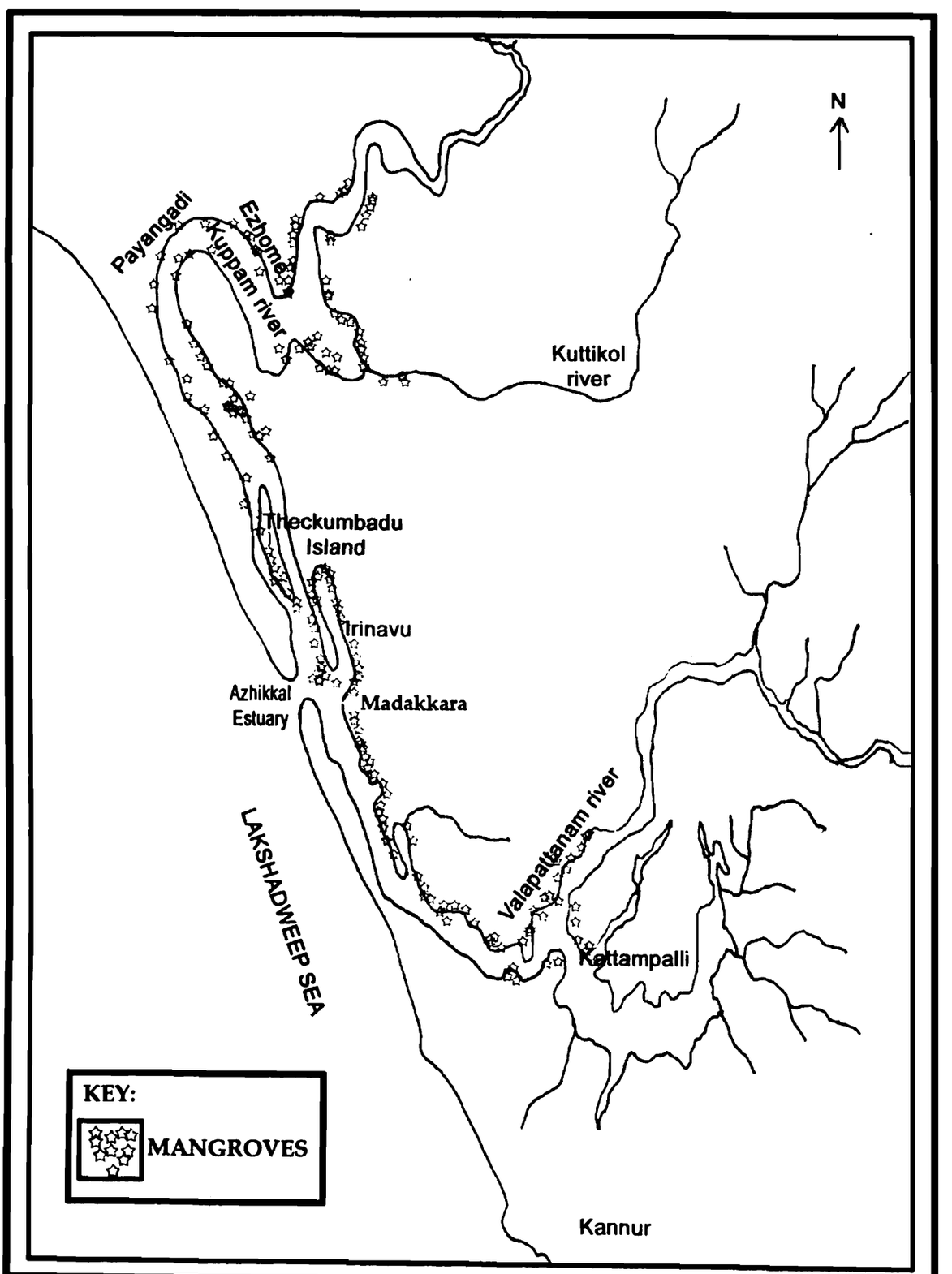


PLATE-1

Fringe mangroves (Thekumabad Island)

Riverine mangroves (Peruvamba River)

PLATE-1. *Contd.*

Estuarine mangroves (Madakkara)

Tidal marsh mangroves (Ezhome)

PLATE-2

Major faunal components of mangroves of North Kerala

Penaeus monodon

Macrobrachium rosenbergi

***Uca* sp.**

***Metapenaeus* sp.**

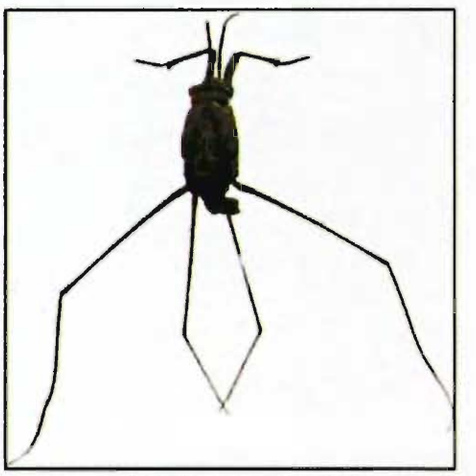
Portunus pelagicus

PLATE-2. *contd.*

Mystus gulio

Cassostrea madrasptensis

Dostia violacea



Halobates galatea

An assemblage of bugs

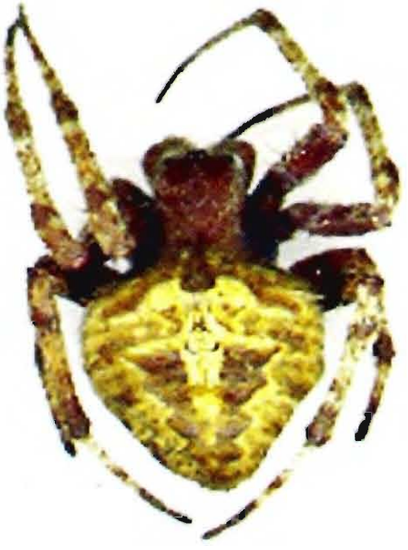
PLATE-3
Faunal associates of mangroves : Spiders

Argiope sp.

Gastracantha geminata

Cyrtophora sp.

Neoscona rumpfi



Neoscona bengalensis

PLATE-4
Avefauna of mangrove ecosystem

Whitenecked Stork

White Bellied Sea Eagle

Brown Headed Gull

Lesser Crested Tern

PLATE-4. Contd.

Masked Booby

Lesser Spotted Eagle

Median Egret

Little Cormorant

PLATE-5
Threats to mangrove ecosystem

Sand mining at Shiriya

Mangrove clearing for Shrimp farming at Kunhimangalam

Rail and road - a cause for mangrove loss

Epidemic outbreak of *Hyblaea peura* infestation on mangroves at Payangadi