FAUNAL DIVERSITY OF MANGROVE ECOSYSTEMS OF KADALUNDI AND NALALLAM, NORTH KERALA, INDIA.

Thesis Submitted for the Degree of
Doctor of Philosophy
in

ZOOLOGY

By

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CERTIFICATE

This is to certify that this thesis entitled " **FAUNAL DIVERSITY OF MANGROVE ECOSYSTEMS OF KADALUNDI AND NALALLAM, NORTH KERALA, INDIA.**" is a piece of authentic work carried out by **Mrs. ARATY SASIKUMAR** in the Department of Zoology, University of Calicut under my guidance and supervision and that no part thereof has been presented earlier for any other degree.

M. Nasser

DECLARATION

I hereby declare that this thesis entitled 'Faunal diversity of mangrove ecosystem of Kadalundi and Nalallam, North Kerala, India' is carried out by me under the supervision of Dr. M.Nasser, Lecturer, Department of Zoology, University of Calicut, in partial fulfillment for Ph.D. degree of the University of Calicut, and also declare that no part of this thesis has been submitted by me for the award of any degree and diploma.

Calicut university campus,
June' 2009

Araty Sasikumar

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INTRODUCTION

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INTRODUCTION

CHAPTER - I

INTRODUCTION

As it is usual when one enters the realm of science, one must first come to terms with the terminology. Scientists often tend to extend the mystique of their subject by devising an elaborate set of terms. The treatment of mangroves has not been immune to this approach.

The term 'mangrove' has applied historically to plants, which live in muddy, wet soil in tropical or subtropical tidal waters. The terminology has tended to fall into disuse recently and term such as 'mangrove forest', 'tidal forest' and 'coastal wood land' have begun to appear from groups of evergreen plants possessing marked similarities in their physiological characteristics and structural adaptations to habitats influenced by the tides. The scientific literature is divided broadly into studies on the biology of individual species of plants or animals in the mangroves and the study of communities that may involve just plants or the relationship between plants and animals.

Mangroves constitute a heterogeneous group of halophytic trees, shrubs and other plants colonizing tidal shores and brackish waters in 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 fresh water inflow (Blasco, 1984; Thom, 1982). The mangrove wetland systems are open systems, which exchange matter and energy between terrestrial and aquatic systems. Mangroves, often seen at the edge of the sea where land and sea interlace, almost blurring the line dividing interface zone between the terrestrial and marine ecosystems, exemplifying diverse habitats, invaluable ecological systems 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 coast line 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% of the mangrove ecosystem of the country. Along the west coast of the country occur 23.5% of the Indian mangroves and the remaining 19.8% is around the Andaman and Nicobar islands. 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 (Radhakrishnan et al., 2006).

Kerala, one of the maritime states of the country with a coastline of about 590 km of the west coast, just over 105 km. of the country's coastline, has only less than 1 % of India's total mangrove ecosystem (Radhakrishna et. al., 2006). The very limited extent of mangroves is disturbed in discrete and isolated patches, mostly confined to the small flats of delta, on the 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 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 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 threatened habitats in Kerala, as anywhere else in the country, or in the world.

Mangrove forests are among the world's most productive ecosystems. They are the only forests situated at the confluence of land and sea in tropical and subtropical latitudes with continuing degradation and destruction of mangrove ecosystem. They are fragile complex and dynamic ecosystem and are dependent on both biotic and abiotic factors that grow between land and sea in tropical and subtropical latitudes.

The major ecological role of mangrove is the stabilization of the shoreline and prevention of shore erosion. The dense network of prop roots, pneumatophores and stilt roots not only give mechanical support to the plant, but also trap the sediments. The rate of sedimentation or accretion is generally much higher in these estuaries lined with mangroves.

The second important ecological role of mangroves is the detritus, which help in feeding and provides breeding and nursery grounds for the juveniles of many commercially important shrimps and fishes. Major primary production in the mangrove ecosystem is from trees. However, only a fraction of this production is consumed by herbivores. The remainder enters the mangrove water as litter fall. The decomposition of this litter fall produces detritus, which in turn is colonized by heterotrophic microorganisms thus enhancing its nutritive value. The detritus, besides forming a food source for suspension and deposit feeders, is also consumed by the juvenile of a variety of bivalves, shrimps and fishes, which migrate into the mangrove environments during their lifecycle for better feeding and protection. There is a direct correlation between the extents of mangrove forests along a coastline and the fishery as well as shrimp catches from the coastal waters adjoining the mangroves, thus demonstrating the importance of mangroves for sustaining coastal fisheries.

There are different types of faunal communities in mangrove waters, which are dependent on the water components in one way or the other. The planktonic and benthic animal communities also play a very important role in mangrove ecosystem just like terrestrial animals. Bioenergetically significant faunal component, of the mangrove ecosystem play a significant role in maintaining the steady state of the mangrove ecosystem and enhance its biological potentiality.

Fauna in mangrove ecosystem is large and diverse as it includes both terrestrial and aquatic organisms. It is composed of large varieties of zooplankton, benthos, shrimps, crabs, molluscs, insects, fishes, birds, reptiles, amphibians and mammals. The muddy or sandy sediments of the mangroves provide habitats for epibenthic in faunal and meiofaunal invertebrates.

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 hot season. It is followed with the southwest monsoon that continues until the middle of October. 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 type of mangroves at an intertidal site (Mitsch and Gosselink, 1986).

Kadalundi and Nalallam estuary is located in Malappuram and Kozhikode districts respectively. The estuarine marshland area of Kadalundi displays the functional characteristics and role of a mangrove wetland system, although reflecting the ravages born by certain negative impacting forces in the recent past. During low tide, as the tidal flood waters recede, the open area of the estuary up to the eastern end, delimited by the north – south railway track is 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 fringing around a few small islets, in Nalallam. The mangroves- vegetation, however, does not exemplify the features of the healthy stand of mangroves, but mostly with woody patches due to the anthropogenic interferences. Although the mangrove plants comprise primarily, of the species *Avicennia officianalis A.marina, Brugieira cylindrica, Kandelia candel*, etc., assorted assemblages of other halophytic species, like *Rhizophara 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 mud flats formed in the estuary.

The mangroves and the mangrove wetland system in and around Kadalundi and Nalallam 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 to secondary, or tertiary consumers. Monthly sampling of faunal composition (zooplanktons, prawns, fishes, crabs, molluscs, insects and birds) and physico-chemical parameters (dissolved oxygen, free carbondioxide, phosphate, temperature, hydrogen ion concentration and salinity) was carried out at two sites of Kadalundi, and a site of Nalallam estuary which showed seasonal variation. The present objective is to sketch the most important features of mangrove systems giving thrust on faunal diversity features associated with them. An attempt has been made to list out the major fauna, both invertebrates and vertebrates (zooplanktons, prawns, crabs, molluscs, fishes, insects and crabs) of three mangroves sites and provide information on the faunal diversity, numerical abundance, and tolerance to different physico-chemical parameters.

Objectives:

- Analysis of physico-chemical characteristics of the three mangrove sites (two sites of Kadalundi and one at Nalallam).
- To understand the diversity, distribution and composition of fauna (zooplankton, prawn, molluscs, crabs, fishes, insects and birds).
- Spatial and temporal variation of physico-chemical and faunal diversity.
- To study the interdependence of fauna (zooplankton, molluscs and crabs) and their significant linear relation with physico-chemical parameters.

MATERIALS AND METHODS

Araty Sasikumar “Faunal diversity of mangrove ecosystems of Kadalundi and Nalallam, North Kerala, India” Thesis. Department of Zoology, University of Calicut, 2009

MATERIALS AND METHODS

CHAPTER - II

MATERIALS AND METHODS

The area of study included two sites of Malappuram and a site from Calicut, districts of North Kerala. Regular monthly observation was done during the premonsoon, monsoon and post monsoon seasons at site I (Kadalundi 11°03'45.2"N, 75°48'.54E) with comparatively dense mangrove vegetation, site II (Kadalundi 11°07'39.41N, 75°50.03.44E) with patchy vegetation and high anthropogenic disturbances and site III (Nalallam 11°10'55.23"N, 75°49'17.88E) located in the riverine stretch (Plate: 1).

PHYSICOCHEMICAL PARAMETERS

For physico-chemical analysis of the water, triplicate samples from all stations were collected during early morning hours (8a.m. to 11a.m.) from 2002 February to January 2006. Collections were made by using plastic containers of one-liter capacity and were analyzed following the standard procedures given in Strickland and Parsons (1965) and Apha (1985).

Temperature is one of the important parameters affecting physico-chemical and biological changes in water. Temperature shows diurnal and seasonal variations. Changes in the atmospheric temperature have a direct bearing on the surface of water body. Atmospheric temperature, surface water temperature and dipped water temperature were recorded in the field using a centigrade thermometer.

The hydrogen ion concentration was measured using pH meter.

Salinity was estimated by Argentometric method (Strickland and Parsons, 1965). A sample of water was brought in a clean glass stoppered bottle. The precipitable halide halogen in a 10 ml volume of sea water is determined by titration with a silver nitrate solution using a silver nitrate solution using chromate end point. The silver solution is standardized against 10 ml of standard sea water.

Oxygen was estimated following modified Winkler procedure (Apha, 1985) by the addition of divalent manganese solution followed by strong alkali; manganous hydroxide is precipitated and dispersed in the stoppered glass bottle. The dissolved oxygen oxidizes an equivalent amount of divalent manganese to basic hydroxide of higher valency states. When solution was acidified in the presence of iodide, the oxidized manganese again reverts to the divalent state and iodine, equivalent to the original dissolved oxygen content of water is liberated. This iodine is titrated with standard thiosulphate solution.

Carbondioxide was measured by burette titration method using Sodium hydroxide and phenolphthalein as indicator (Apha, 1985).

Phosphate was estimated by allowing the seawater to react with a composite reagent containing Ammonium molybdate solution, stannous chloride, Sulphuric acid and phenolphthalein as indicator and optical density was measured using Spectrophotometer (Strickland and Parsons, 1965).

Fauna were observed from 2002 February to January 2006. Population studies were done for two years (February 2004 to January 2006). Samples from all stations were collected during early morning hours (8a.m. to 11a.m.).

a) **Zooplankton** samples were collected every month for a period of two years from February 2004 to January 2006, using plankton hand net made of bolting nylon cloth of mesh size 45μm prepared according to the design given by Welch (1952). Hauls were made manually in early morning hours (between 8 to 11 a.m.).

The procedure for collection, storage and analysis of samples was followed as described in standard methods (Apha, 1985). Hauls were made manually by dragging the net from one end to the other end of different sections of mangrove area, by slightly agitating the water column without stirring the mud. The water from the bucket was sieved through the bolting nylon cloth. All samples were fixed immediately and preserved in 4% neutral formalin solution.

The samples were tagged for taxonomical and numerical studies. The individuals were sorted out and their whole mounts were stained with Acetocarmine, Lugols iodine or methylene blue, according to their requirements and subjected to microscopic photography using Axioskop 2 plus Zeiss trinocular resolution microscope.

For the numerical estimation, the organisms were observed under light microscope using 'Sedgewick Rafter cell' as per the procedure given in the standard methods (Apha, 1985). Average of six counts for each sample was taken into account and results are expressed as number of organisms per liter by using the formula: $n = (a \times 1000)\, c / L$

Where, n = number of planktons per liter of water

a = average number of plankton in 1 ml of sub sample

L = volume of original water sample in liter

c = ml. of plankton concentrate

b) **Prawn** samples were collected using plankton hand net made of bolting nylon cloth of mesh size 45μm. The hauls were made manually and operated at random in each sampling site from six quadrates 2m. on a side. Collections were preserved immediately in 10% formalin in sea water. Adults were counted from each collection and identified with the help of efficient taxonomists. Quantitative estimation was based on number of individuals obtained per unit area.

c) **Crab** collections were made during low tide. Density of the crabs were estimated by using 50 × 50 cm. quadrate either by counting the number of crabs active on the substrate enclosed by the quadrates or procured by hand picking or by digging crabs from their burrows. In each site ten samples were collected (five horizontally and five vertically from high tide mark up to water level) to estimate the abundance and preserved in 4 % formalin solution.

d) Shore collections of **molluscs** were made by marking ten quadrates each of 1 m^2. All molluscan species on the ground as well on the mangrove plants enclosed by the quadrates were collected and counted. Quadrates were laid at 5m interval. All species were preserved in 4 % formalin solution, shells were cleaned dried and preserved.

e) **Insect** collections were made by day for a period of two years. At each sampling site six quadrates each of five square meters was marked. Infested mangrove logs and fruits were keenly searched, scanning the foliage, flowers, trunks, branches etc. Insects that were spotted were collected in plastic containers and with the help of collecting net. Insect net used for collecting individual specimens when they are in flight or at rest on flowers or shrubs were made with an aluminium handle 120 cm. length with an metal opening 30 cm. in diameter and net bag about 90 cm. deep tapered at the bottom.

General collection was made by sweep net. Insects are removed by hand, forceps or an aspirator. A beating tray is also used (an umbrella placed upside down was used. Captured insects were transferred to killing bottles moistened with ethyl acetate, dried and preserved in a storage box. Small insects were preserved in 70 % alcohol.

Arthropods collected were identified where ever possible up to species level, with the help of efficient taxonomists. Quantitative estimation of arthropods based on number of individuals of the species obtained divided by total number of quadrates used in sampling.

e) **Fishes** were collected with the help of cast net, scoop net and gill net monthly for a period of 2 years from February 2004-to January 2006.

Preserved in 10 % formalin solution for identification and identified up to species level, with the help of efficient taxonomists.

f) **Birds** observation was carried out during early morning hours. Area mapping, line transect and point transect are some of the standard methods used for counting birds. Area mapping requires less time but cover more area. The point transect produces more accurate estimate of bird population, but a wide area can be covered in unit census time by line transect method (Gaston, 1974).

Statistical Analysis

Analysis of variance (ANOVA $\alpha = 0.05$) was performed to compare the seasonal variation in the physico-chemical parameters and the faunal density in the site and between the three sites.

Simple correlation coefficients were computed to detect linear relationships between faunal (zooplanktons, crabs and molluscs) density values and physico-chemical parameters.

LITERATURE REVIEW

Araty Sasikumar “Faunal diversity of mangrove ecosystems of Kadalundi and Nalallam, North Kerala, India” Thesis. Department of Zoology, University of Calicut, 2009

LITERATURE REVIEW

CHAPTER - III

LITERATURE REVIEW

Mangroves are one among the world's most productive ecosystems. There may be no other group of plants that have developed such adaptations to extreme conditions of high salinity, extreme tides, strong winds, high temperature and muddy anaerobic soils. Regarding environmental significance, the mangroves protect the coastal communities from cyclones, storms, flood and prevent soil erosion. Regarding economic benefits, the mangrove promote coastal and marine fisheries, yield forest products and provides site for eco tourism.

The mangrove create unique ecological environment that host rich assemblages of species (Kathiresan and Bingham, 2001). Mangrove ecosystem serves as the reservoir of species of plants and associated animals (Gopinathan and Selvaraj, 2005). While studying the coastal and marine biodiversity of India, Venkataraman and Wafar (2005) observed 1862 species of mangrove associated fauna. In India a total of about 41 genera belonging to 29 families of mangrove plants have been reported (Duke, 1992). About 94% of the mangrove biomass is of direct importance to regional fishery in Southern Queensland (Christopher, 1997). Mangroves are an investment in erosion control and enhance the fertility of coastal habitats (Kathiresan and David, 1998). Presence of mangroves is an index of shore fertility and fishery resources. The long-term ecological and genetic value of the mangrove outweighs the short term value as a source of fodder, fuel and sink to our land based pollutants. Contribution of mangrove ecosystem to coastal environment, biodiversity and to livelihood of coastal populace is poorly understood, leading to indiscriminate destruction of these vital ecosystems. It is therefore essential to develop management plans which enable extraction of resources and services from mangrove ecosystem, in a sustainable way without jeopardizing the resource base (Kalyan, 1987; Balachandra, 1988; Ranjithkumar and Kathiresan, 1996; Kathiresan, 1996; Deiva, 1998; Kathiresan and David, 1998; Thivakaran, 1998; Brenda et al., 1998; Kathiresan and Sivasothi, 2002 and Kathiresan and Rajendran, 2003).

The mangroves have received inadequate and insufficient attention in the past. Globally mangroves are under tremendous human pressure. Biodiversity in mangroves is rapidly decreasing (Nandan, 2002; Kathiresan and Rajendran, 2003) due to human encroachment and for forestry and fishery products. Due to several natural and anthropogenic pressures, globally mangroves forests are being destroyed every year, this scenario has called for a conservation strategy that can expedite the restoration of degraded areas at a faster pace (Kalyan, 1987; Rajivkumar, 1995; Lee et al., 1996; Kathiresan, 1996, 1998, 2002; Mahanta, 2000 and Upadhyay et al., 2002). Surface structures of Achara mangrove areas are disturbed due to activities like soil mining and bund repair (Chavan and Gokhale, 2005). The data collected by Kathiresan (2002) reveals that the causes of natural degradation of mangroves are mainly due to high salinity, low levels of available nutrients and poor microbial counts in the soil substrates. Status of mangrove ecosystem in Bhitarkanika and Singapore showed that these habitats have been shrinking due to anthropogenic disturbances like increase in habitations and pollution (Ranjithkumar and Kathiresan, 1996; Kathiresan and Sivasothi, 2002, Rao et al., 2003).

The study of different water chemical parameters (Vijayalakshmi et al., 1983; Goswami and Devassy, 1991; Ramanathan et al., 1993; Lalithambikadevi, 1993) showed fluctuation due to rain and land drainage.

Air **temperature** associated with sea surface temperature and oceanic currents in winter were found to be the primary factor affecting the diversity and distribution of mangroves in Taiwan (Mei and Hsun, 2000). Studies in estuaries of Goa (Singbel, 1973; Verma, 1995 and Sunita and Rama, 1995) showed that fluctuation in temperature was due to increased fresh water inflow caused by rain in the catchments. Studies conducted on the physico-chemical parameters of estuaries indicate that maximum temperature was observed in premonsoon due to land drainage (Kondala, 1984). Gupta et al., (1980) observed high water temperature during premonsoon and subsurface waters were warmer than surface water due to the influx of warmer tidal water in Nethrapur-Gurupur estuary. The slight decrease of water temperature with depth was due to the heating effect of the sun on the surface water and the transference of heat throughout the water column by mixing process (Saad, 1977) and large variation in temperature was found to influence the flora and fauna of the estuaries, especially the bottom communities (Sankaranarayanan and Qasim, 1969).

Dehadrai (1970) and Haridas et al., (1973) noted that dissolved **oxygen** in the estuarine environment is chiefly controlled by tidal ingress and fresh water runoff and showed higher oxygen values during the period of intense precipitation. According to Hubertz and Cahoon (1999); Wenner and Geist (2001) and Ricardo et al., (2002), dissolved oxygen levels may vary on daily basis due to photosynthetic and metabolic processes, as well as with tidal cycles. Result presented by Ringwood and Keppler (2002) suggests that the ability of estuarine organisms to tolerate dissolved oxygen stress is related to the pH conditions i.e. animals may be able to tolerate lower dissolved oxygen conditions if pH remains high. The large variation in dissolved oxygen observed during the study is expected to influence profoundly the flora and fauna of the estuaries, especially the bottom communities. Sankaranarayanan and Jayaraman (1972); Singbel (1973) observed that large variation in oxygen is due to rain water inflow. Studies on hydrobiology of Pichavaram mangrove (Perikali and Eswaramoorthi, 2000) revealed that organic load carried by water bodies in the form of sewage wastes lead to depletion of dissolved oxygen and very high sulphide content water.

Studies on physico-chemical parameters of different water bodies showed levels of high concentration of **nutrients** due to land drainage, untreated domestic sewage and sluggish circulation in the bar built estuary (Seshappa, 1953; Rashid, 1980; Olausson and Cata, 1980; Balakrishnan et al., 1984; Antoni et al., 1990; Sunita and Rama, 1995; Rajendran, 2000; Perikali and Eswari, 2000; Bazmi and Ahmad, 2006). Hydro biological studies of Vellar estuary (Chandran and Ramamoorthi 1984a, b) indicated that seasonal variation of nutrients was mainly enriched by land runoff with pronounced tidal variations.

Decrease in the **phosphate** in the estuarine environment during monsoon was attributed to greater silt load and high turbid condition resulting in removal of phosphorous from solution (Haridas et al., 1973; Ramanadhan and Varadarajulu, 1975; Purushotaman and Bhatnagar, 1976; Bhunia and Choudhury, 1982; Lakshmanan et al., 1983; Nair et al., 1983 and Rajagopal and Reddy, 1984). Low phosphate values were encountered during the summer and early pre-monsoon months, mainly due to their utilization by phytoplankton population which was high during or just before this period (Chandran, 1982; Dehadrai, 1970: Vijayalakshmi and Venugopalan, 1973). Variation may also be caused by various process like adsorption and desorption of phosphate and buffering action of sediment under varying environmental condition (Pomeroy et al., 1972). The high concentration of phosphates observed during August may be due to the runoff from the irrigation channels and release of phosphate from sediment due to stirring action by strong winds (Chandran and Ramamoorthi, 1984b). Studies on the hydrography of the estuarine and inshore waters of Goa (Singbel, 1973) showed that large variation in phosphate is due to inflow of water resulting from rain. Salinity variation due to river discharge during monsoon and high value of phosphate during premonsoon indicated extremely polluted conditions of Paravur (Shibu et al., 1990).

The increase of **pH** is usually correlated with photosynthetic activity. The high pH value in monsoon give a good evidence for phytoplankton abundance in better environmental conditions as well as general stability of water (Saad, 1977). According to Gupta et al., (1980) and Bhat and Gupta (1980) low pH prevailed during May and subsurface waters were warmer than surface water due to the influx of warmer tidal water in Nethrapur-Gurupur estuary. Results presented by Ringwood and Keppler (2002) suggests that the ability of estuarine organisms to tolerate salinity or dissolved oxygen stress may ultimately be related to the pH conditions i.e. animals may be able to tolerate lower salinity or lower dissolved oxygen conditions if pH remains high.

Mangrove forests are confined to high **salinity** areas, although productivity has been shown to increase with the availability of fresh water (Pool et. al., 1977). Salinity and tidal fluctuations in the mangrove swamps are the critical factors that regulate the physical and chemical environment of entire biota of Sunderbans (Kalyan, 1993). Studies in Gamtoos estuary showed fluctuation in salinity structure occurred due to increased fresh water inflow caused by rain in the catchments (Singbel, 1973). Studies conducted on the physico chemical parameters of estuaries indicate that minimum salinity observed during monsoon was due to land drainage (Nagarajah and Gupta, 1983). Kondala (1984) revealed that low salinity generally favour removal of phosphorous. Hubertz and Cahoon (1999); Wenner and Geist (2001) and Ricardo et al., (2002) provided knowledge on the fluctuation and ranges of conditions that estuarine organisms face and found that salinity may vary episodically due to rain. Ramanathan et al., (1993) while studying the geochemistry of the Cauvery estuary showed that the salinity ranged from 0.45 ppt to 18 ppt and specific conductance showed a sharp increase toward the lower reaches due to mixing phenomena. Salinity distribution patterns in the Vasishta-Godavari estuary showed increased salinity with rising tide and decreased with falling tide (Kumar et al., 2003). Chandramohan and Sathyanarayana (1972); Dehadrai and Bhargava (1972); Gopinathan (1975); and Ragothaman and Ramachandra (1982) while studying the hydrobiology of estuaries of east and west coasts observed considerable variation in salinity which has direct influence on population of plankton secondary production and change in coastal biodiversity.

The seawater is the dwelling place for a large variety of organisms. However, it is like a multi-storied building where the inhabitants of the first floor are not exactly similar to the other floors. There are different types of faunal communities in mangrove waters, which are dependent on the water components in one way or the other. The planktonic and benthic animals play a major role in the mangrove ecosystem just like the terrestrial animals (Ray et al., 2000). In the context of global loss of thousands of species because of pollution and habitat destruction, assessments of species diversity and richness are highly needed (May, 1986).

Several notable studies on various aspects of **plankton** have been conducted in coastal, offshore and estuarine environments of both east and west coast of India. Considerable data are available on the ecology of zooplankton of the estuarine and backwaters along east coast (Thangaraj, 1984 and Sarkar et.al., 1986). Along the west coast, notable works have been conducted on the ecology of zooplankton of Mandovi, Zuari and Nethravathi estuaries (Goswami and Selvakumar, 1977; Nair 1980a, b; Goswami, 1982; Arunachalam et al., 1982; Nair et al., 1983 and Bhat and Gupta, 1983; Venkitaraman and Das, 2001). Salinity was observed to be an important parameter regulating the spatial and temporal variation of zooplankton biomass (Banargee and Choudhury, 1966; Sasi et al., 1999; Prasad, 2003). Reports are available on various aspects on the ecology and taxonomy of plankton communities in different mangrove ecosystems. Studies conducted by Sasi et al., (1999) reports that mangrove fringed coastal lagoons is productive at the primary and secondary level, particularly during the premonsoon and post monsoon months. Seasonal variation was observed among zooplankton with least production during monsoon and reduced salinity in a mangrove fringed lagoon of south west coast (Sasi et al., 1999) and pre monsoon period was observed to be highly productive (Haridas et al., 1973 and Pillai et al., 1975).

The hydrographical parameters undergo considerable variation due to the seasonal, climatological changes and temporal distribution of planktonic communities. Many workers have studied the relationship of zooplanktons with various parameters, Sarkar et al., (1986) and Eswari and Remani (2004) observed seasonal distribution of copepods showing higher abundance during summer period having high salinity values was recorded from Hooghly estuary. Studies on the influence of spatial and temporal variations in the occurrence and abundance of copepod species in Mandovi –Zuari estuarine system indicated that salinity exerts maximum influence along with location, turbidity, currents and availability of food (Goswami, 1982; Vijayalakshmi et al., 1983; Sarkar et al., 1985; Goswami and Devassy, 1991). On the basis of zooplankton abundance, the Vengarla (Goswami, 1985), Maharashtra coast (Vijayalakshmi et al., 1983) and Mandovi –Zuari (Goswami and Devassy, 1991) regions appear to be potentially rich fishing grounds for the pelagic fishery. Various studies have been conducted on the zoo and phyto plankton of mangrove environments in different regions of the world. While studying the biodiversity of zooplanktons at Pichavaram mangroves, Karuppuswamy and Perumal, (2000) observed that maximum density and diversity was recorded during summer and it could be related to high salinity and stable hydrographical features. Ninety species of zooplankton was recorded from Muthupet mangroves (Kalidasan, 1991).

Proliferation of plankton due to nutrient enrichment caused by upwelling (Sankaranarayanan et al., 1978) and land run off along with lowering of temperature and salinity during monsoon (Goswami, 1985) was observed. Benthic organism constitutes an important component of the food web of an estuarine ecosystem. To obtain a comprehensive account of fishery potential of estuarine, backwaters etc. knowledge of benthic fauna is imperative. According to Devassy and Gopinath (1970) benthic fauna of marine, gradient and tidal zones of Vellar estuary exhibit a similar species composition, relative abundance of individuals comprising each species varied considerably. It was observed that in shallow estuarine systems, where the flow of water is continuous, dissolved oxygen might not be a limiting factor for benthic fauna (Parulekar and Dwivedi, 1975; Parulekar et al., 1975; and Chandran et al., 1982). According to Kurian et al., (1975), in tropical estuaries the effect of temperature and pH as a limiting factor is only of secondary importance, that is, seasonal change in temperature could not be correlated on benthic faunal production or distribution since variation in bottom temperature was not conspicuous and salinity appeared to have some effect on distribution of benthic fauna.

Studies on estuarine and coastal water benthic communities showed no significant correlations between the number of total fauna and seasonal fluctuation in the environmental parameters (Damodaran, 1973;

Nair et al., 1984; Prabhadevi, 1994). Seasonal variation in benthic population of Colerron estuary (Jagadesan and Ayyakkannu, 1992) records maximum counts during summer and post monsoon seasons due to nature of silty substratum and low density in monsoon was due to low salinity as a result of monsoonal flood. Distribution of benthic ostracods showed abundance during warm weather season. Krishnamoorthy and Subrahmanian (2003) and Ashok et al., (2005) observed maximum population of microplankton and meroplankton respectively during summer in Parangipettai.

Studies pertaining to the taxonomy and diversity of fresh water **prawns** showed that mangrove areas play an important role as nursery grounds for many fishes especially shrimps, because the environmental characteristics of tropical estuaries undergo short term variations in terms of nutrients (Jayachandran, 2001; Raghunathan and Valarmati, 2005 and 2006 and Raghunathan, 2006). Nine specimens of eulittoral Palaemonid shrimps were reported from Vishakapatnam coast (Ravindranath, 1978) and five from Goa (George, 1977). Kalidasan (1991) reported five prawn species from Muthupet mangroves.

Achuthankutty (1988) while studying the nursery life of *Metapenaeus dobsoni* observed post monsoon as the active breeding period and salinity did not seem to play a decisive role in immigration and growth. Estuarine distribution of prawns appeared to follow the salinity displacement, the animals being found at river stations during summer and autumn when saline encroachment of the estuary was greater suggesting that reproduction does not take place in fresh water (Kneib, 1987). According to Kinne (1963) temperature and salinity fluctuations at least level is unimportant to intertidal decapods that are physiologically adapted to these conditions. Long-term experiments on the effect of salinity and temperature on the survival and growth of the post larvae of *Penaeus indicus* indicate that the ideal combination of salinity and temperature is 10ppt to 20 ppt at 19°c to 32°c respectively (Bhattacharya and Kewairamani, 1970).

Detailed studies conducted in India on food and feeding habits of *Metapenaeus monoceros* from Cochin (Nandakumar and Damodaran, 1998) showed that penaeid prawns are omnivorous scavengers or detritus feeders and feed more in nights than in day hours. Biologically and economically, one of the most important aspects of man-mangrove interaction is the mangrove dependent or associated capture and captive fisheries and aquaculture (Silas, 1987). Parulekhar (1985) and Krishnamurthy and Jayaseelan (1986) have drawn attention to the significance of aquaculture in the mangrove ecosystem of India. The substratum mixed with mangrove detritus below the mid tide zone is more suitable for the juvenile prawns that virtually provide an additional habitat (Krishnamurthy and Jayaseelan, 1986). Mangrove areas serve as feeding, breeding and nursery grounds for many commercially important shell and fin fishes, in addition to providing shelter for the juvenile stages of these groups (Rajagopalan et al., 1986). Moreover, juveniles emerge when the late larvae metamorphose and settle at the bottom and cling to the vegetation of submerged objects (Kurian and Sebastian, 1993). It can be inferred from the studies conducted by Sunilkumar (2001) that mangrove soil provides a favorable shelter for the juveniles of *Macrobrachium rossenbergii*. Juveniles of *M.rossenbergii* feed on small worms, crustaceans and plant materials (Kurian and Sebastian, 1993). Sunilkumar (1995) reports that the intertidal areas of mangrove ecosystem of Cochin waters consisted of variety of soil dwelling polychaetes, crustaceans and other invertebrate organisms. Dietary potential of cholesterol in the diet of *P. indicus* extracted from *Rhizophora* (Ramesh and Kathiresan, 1992) revealed that it promoted growth, conversion efficiency and biochemical constituents of prawns. It has been reported by Vasques et al., (1989) that high levels of hardness may depress prawn growth rate and optimum growth can be expected at hardness level between 20mg/l to 200 mg/l. Studies on the seasonal diel recruitment pattern showed the water temperature and salinity variations were meager, while lunar phases, diel cycles and tidal oscillations influenced their occurrence (Natarajan et al., 1986; Selvakumar et al., 1987; Achuthankutty, 1988 and Goswami and Usha, 1992).

India harbours an approximate 3,271 species of **molluscs** (Mitra and Dey, 1992). On the other hand, a checklist of molluscs of Indian estuaries includes 245 species (Rao, 1985). In India studies on estuarine molluscs of Chilka lake (Annadale and Kemp, 1915), of Gangetic delta by (Annadale and Prashad, 1919, 1921), of Kakinada bay and Godavari estuary by (Radhakrishnan and Ganapati, 1967, 1969), of Mahanadi estuary by Rao and Mookherjee, 1968) and of Godavari estuary (Radhakrishna and Janakiram, 1975) revealed that they are the most dominant fauna in these ecosystem. Species of Littorina and Neritina are generally found crawling on the stems and branches of mangroves (Rao, 1968). The molluscan fauna of Gangetic delta is very rich and belongs to the families Neritidae, Littorinidae etc. and occur in large members on mud flats exposed during low tide and even on the trunks, branches and roots of mangrove trees (Annadale, 1922).

Intertidal and monthly variation in the macro fauna resulted due to tidal fluctuation and surface sediment organic content (Netto and Lana, 1997; Cantira et al., 1999; Cheng et al., 1999; Skilleter and Warren, 2000; Kathiresan et al., 2000). Species succession of macro fauna of Goa estuaries were studied (Harkantra and Rodrigues, 2003) and the results revealed that the southwest monsoon and local biotic and abiotic factors mainly influenced species succession. According to Pedro et al., (2001) species succession is influenced by high temperature in summer in Quele estuary.

While studying the distribution of meobenthos of Gautami and Godavari estuarine system, occurrence of highest density of meiobenthic *Harpacticoid* copepods in a mangrove biotope compared to their intertidal stations were due to clayey-silt sediments in mangrove ecosystem (Kondalarao, 1984). Studies on molluscs in various estuarine ecosystems revealed that gastropods are ecologically very intimate group in the mangrove ecosystem and constitute a considerable part of benthic fauna (Preston, 1915a, b; Sarma and Tapas, 1990; and Sunil Kumar, 1995, 2001).

Wood borers of brackish waters of Great Nicobar islands are recorded by Rajagopal and Daniel (1969) and destruction caused by marine woodborers to mangroves from Sunderbans (Roonwal, 1954 a,b), Veraval (Santhakumaran,1973), Great Nicobar islands (Das and Devroy, 1980), Lakshwadweep (Nair and Dharmaraja, 1983), South Andaman (Santhakumaran,1996) and along Indian coasts (Aarti, 2006) from Achara creek revealed that this group doesn't cause any damage to healthy plants and are often found on fallen trees. Juan and Jaime (1998) recorded maximum occurrence and density of gastropods in sediment substratum owing to high abundance of mangrove detritus. The variation of habitat preference of *Hydrobia* species in a mangrove ecosystem is correlated to difference in the texture and nature of the mangrove substratum (Kumar, 2002). Mangrove trees support a benthic fauna similar to those found on other hard substrata.

During an intensive survey of the macro benthos of Cochin mangroves, Sunilkumar (1993, 1999) revealed the occurrence of mud snail, *Hydrobia*, the first record from Indian mangrove environment. Pillai and Appukuttan (1980) while studying the molluscs in and around the coral reefs of south eastern coast of India compared the mangrove associated molluscs and stated that Indian mangroves have faunal elements from both eastern and western parts of Indian Ocean. Kalidasan (1991) and Kathiresan and David (1998) recorded eighteen species of molluscs from Muthupet mangroves and eleven species from Australian mangroves respectively.

Das and Devroy (1980) recorded eight species of wood boring bivalves from South Andaman and two species of *Teredinid* bivalves from the middle Andaman mangroves of which seven species constitute the first record. (Ganapati and Rao, 1959). Ganapati and Rao (1960) recorded five species of marine wood boring isopods of the genus *Limnoria* from Port Blair and Tiwari et al., (1980) recorded eleven species of wood borers of mangroves of Andaman and Nicobar Islands. Tonapi (1970) recorded twenty-one species of molluscs belonging to nine families and seventeen genera from Poona. Kalyanasundaram and Granti (1975) mentioned the occurrence of four species of molluscan borers from Andamans. According to Radhakrishna and Ganapati (1969), there is a paucity of molluscs' both in variety and number in Gautami-Godavari estuary, which is attributed to the net effect of strong currents, lack of suitable and stable substratum, absence of submerged vegetation and marked seasonal variation in salinity. Salinity tolerance of gastropod species is generally influenced by the salinity regime of its habitat. In tropical waters, salinity and temperature were known to play a key role in distribution of near shore animals (Thivakaran and Kasinathan, 1990).

The aquatic habitat associated with mangrove wetland and its surroundings, including estuaries and vast areas of brackish waters supported and sheltered the populations of communities of Crustaceans. Under these faunal categories, the communities of crabs and shrimps dominated the scene.

Reports are available on diversity of ten species of mangrove **crabs** from Sunder bans (Ajithkumar, 1975) and a total of 38 Brachyuran species recorded from Pichavaram and 8 species from Vellar estuary (Ajmal et al.,2005). Fifty species of Brachyuran crabs under 31 genera have been reported from mangrove habitats of India (Dev and Das, 2000). Eighteen species of Brachyuran crabs under nine genera and four families are identified from Sunderbans mangrove ecosystems (Chakraborty and Choudhury, 1992). Kathiresan and David (1998) observed three species of crabs from Australian mangroves and Kalidasan (1991) nine species from Muthupet. First report for the occurrence of hermit crab *Dardanus setifer* from the northern part of west coast was made by Nayak and Kakati (1977) and *Demania shyamasundari*, a Brachyuran from Waltair coast by Nirmaladevi (1990). Lawrence (1974) observed twenty and Johnson (1970) nine species of crabs from various mangrove ecosystems. Survey conducted by Radhakrishnan et al., (2006) at various mangrove areas of Kerala observed twenty species of crabs. Vijayakumar and Kannupandi (1987b) reports that *Sesarma brockii* is one of the most dominant species in Pitchavaram mangroves and is available throughout the year.

Crabs play many important roles in mangroves. Degradation of mangrove leaf litter by crabs, which contain nitrogen, carbon, phosphorus and trace metals form a rich source of food for other consumers (Kuraeuter, 1976 and James et al., 1979). Their burrowing habit aids in aeration and free circulation of water, which promotes growth of seedlings, recycling of nutrients by ploughing, break down of particulate organic matter by exposing them to microbes (Diemont and Vanwijngarden, 1975) and they form the food for many birds, snakes and predatory fishes and their larvae are also consumed by many carnivores (Macintosh, 1984).The feeding activities of detrivores crabs helps in the degradation of organic matter, especially mangrove litters and decaying woods (Chakraborty et al., 2005). Odum (1971) found that fecal pellets of crabs were important dietary component of abundant fishes in mangrove ecosystem. According to James et al., (1979) ecological role of *Aratus pisonii* includes herbivory, predation and export of biomass and energy in the form of offspring and frass in mangrove ecosystem.

James et al., (1979) observed that the size and density of the crab population depend on habitat. Seasonal oscillation of different hydrological parameters, different degree of tidal amplitude and rate of siltation render complex environment for macrobenthic fauna of mangrove ecosystem (Choudhury et al., 1984). Teal (1958) observed that the most important factors influencing the distribution and abundance of *Uca* species are the substratum, salinity and competition in the biotic system. Ecological factors that influence crab diversity are substrate characteristics, the presence and absence of mangrove vegetation, the salinity and the degree of tidal inundation and exposure (Icely, 1976). Report by Chakraborty (1984) reveals that as the temperature within the burrow of crab does not fluctuate in relation to the temperature of air and soil, the temperature is not supposed to play a great role in zonation of crabs. Mangrove crabs are susceptible to changes in salinity and influence of salinity on larval development of mangrove crab showed 25 ppt. as the optimum (Ravindranath, 1977; Vijayakumar and Kannupandi, 1987 a, b; Selvakumar et al., 1987; Krishnan and Kannupandi, 1987; Chakraborthy and Choudhury, 1992; Balagurunathan and Kannupandi, 1993; Shen and Lai, 1994; Kannupandi et al., 1997; Kannupandi etal., 2000 and Younis and Shigemitsu, 2002). According to Selvakumar et al., (1987) each larval stages of crabs show different optimal salinity. Studies conducted by Kannupandi et al., (1997) reports that each zoeal and megalopal stage requires different optimal salinity to complete larval development of *Thalamita crenata*. Distribution and relative abundance of intertidal hermit crabs are influenced by salinity and availability of shells (Ajmalkhan and Natarajan, 1981).

There have been number of studies of the seasonal distribution of Brachyuran larvae. Results of these investigation shows that these

Brachyuran species spawn during warmer months of the year, which is related to acceleration of developmental rates at higher temperature (Lough,1975), and to the greater availability of planktonic food during late spring and summer (Flemer, 1970; Epifanio and Dittel, 1984).

Mangrove entomology remains a neglected field of study. While studies conducted in the rain forests of tropics have brought to light a multitude of insect species and generated an increased amount of interest among entomologists worldwide, the insect fauna of mangrove has somehow failed to elicit sufficient interest.

Earlier studies on **insect** fauna of mangroves mentioned only the presence of biting midges, ants, mosquitoes and fireflies (Walsh, 1974; Chapman, 1977). The general belief seems to have been that the mangals do not support a distinct insect fauna and that the majority of animals recorded in them either come from the adjoining terrestrial vegetation or are characteristic of saline mud flats irrespective of whether they support a vegetation cover (Chapman, 1976). Although Murphy's (1990) work has helped at least to partially dispel this belief, he discovered that many canopies harboured a much greater diversity of insect herbivores; he observed about 100 species of herbivores from the Singapore mangroves.

Johnstone (1981) observed that up to 20% of leaf areas were removed by insect herbivore in mangrove forests in New Guinea. A study conducted by Robertson and Duke (1987a) indicates that grazing insects appear to be relatively unimportant in transferring energy and materials in mangrove forests. According to Hutchings and Recher (1982) there are abundant ants and termite fauna in mangroves of northern Australian mangrove which have an important influence on the turnover of wood biomass. Extensive survey for insect herbivore of Andaman and Nicobar islands were conducted (Veena et al., 1997), where a total of 197 species of herbivores, 43 species of hymenopterans parasitoids and 36 species of predators were found. Over 72 species of insects belonging to seven orders have been listed from Sunderbans (Choudhuri and Choudhury, 1994). Ken-ichi-Abe (1988) reported that three insect orders namely Hymenoptera, Diptera and Psocoptera composed the arboreal fauna in mangrove ecosystem of Halmahara. Observation suggests that bees *Apis florida* and *Apis dorsata* promotes pollination of Muthupet mangroves (Deiva, 1998). He observed 113 species of insects. Three species of mosquitoes are reported from Sunderbans, (Naskar and Guhabakshi, 1987), Pichavaram (Thangam and Kathiresan, 1993), and Muthupet (Deiva, 1998). The mangroves are also home to some rare and interesting species of moth and butterflies in Borneo. The atlas moth *Attacus memulleni* Watson and nymphalid butterfly *Polyura schreiber andamanica* Tsukuda, lives and completes their life cycle in the mangals (Holloway, 1993).

Abundance and seasonal fluctuations of two tabanid insects were studied in relation to some important environmental parameters. Maximum distribution was observed during post monsoon and minimum during pre monsoon. Soil temperature, soil moisture, salinity, dissolved oxygen, pH, organic carbon and available phosphorus appear to be the major factors controlling their distribution (Ray and Choudhury, 1994). Mangrove biologists had all along reasoned that the leathery texture of the foliage and the higher content of these species deterred insects from feeding on them (Tomlinson, 1980). Naskar and Mandal (1999) recorded the rock bee, *Apis dorsata* as the main pollinator of Blinding tree in Sunderban mangroves. Jafer and Radhakrishnan (2001) observed that the cat-like male inflorescence with yellow coloured fragrant flowers of *Exocaeria agallocha* attract a wide variety of insects and identified 10 species of butterflies from Kannur.

Although investigations on the marine woodborers of mangrove ecosystem have been made in detail, very little is known regarding the terrestrial insect borers of this ecosystem. Stebbing (1914) was first to record an insect pest of mangroves in India. He reported that *Diapus heritierae* Stebbing bores into both green and half-dry wood of *Heritiera littoralis.* Beeson (1941) reported forty-seven insect species of which seven where insect borers of mangrove plants which constitute the first record of mangrove pest from Andaman and Nicobar islands. Eleven species of insect borers have been reported to affect mangrove plants in Bay islands (Das and Dev, 1982; Das et al., 1987; Dev et al., 1984 and Tiwari et al., 1980). Das et al., (1988) reported sixteen species of insects of which ten where wood borers, one a stem borer and three fruit borers, while two where borers of both fruit and germinating seedlings. Hill and Newberry

(1980) found *Avicennia marina* commonly infested by *Icerya seychellarum.* Tiwari et al., (1980) observed two species of Cerambycid beetle causing damage to wood of mangroves of Andaman and Nicobar islands. Kathiresan (1993) identified *Aspidotus destructor* Sign. infecting the viviparous seedlings of *Rhizophora mucronata* Lamk. Kalshoven (1953), Kapur (1958) and Piyakaranchana (1981) reported severe defoliation of *Avicennia alba* by larvae of *Cleora injectaria* Walker. Anthony and Sengii (1986) found *Ophiusa melicerata* a noctuid moth caterpillar defoliating *Exocaeria agallocha.* Four species of insect borers comprising two species of Cerambycid beetles, one species of curculionid beetle and moth of the family Pyralidae were found to bore in to the fruits of mangroves of Andaman and Nicobar islands (Dev et al., 1987).

Maximum number of insects was observed during postmonsoon period, notably during the lush green phase of growth followed by flowering phase of mangrove flora. Radhakrishnan et al., (2006), reported a diversity of 33 species of hymenopterans and 23 species of Odonates. One exceptional observation was that of the epidemic infestation of larval teak defoliator *Hyblaea pleurea* on mangrove strands at various places in Payangadi (Jafer and Radhakrishnan, 2004). Radhakrishnan and Thirumalai (2004) reported the occurrence of the sea skater *Halobates galatea* in a mangrove habitat at Dharmadom. Radhakrishnan and Rao (1987) documented 450 insects species associated with mangrove ecosystem of Kerala.

Knowledge of bottom fauna is a prerequisite for the determination and development of fisheries. Several investigations were made on the distribution and abundance of benthic communities. One of the most important aspects of man-mangrove interaction is the mangrove dependent or associated capture and captive fisheries and aquaculture. Reports on **fish** fauna of mangrove creeks of Taiwan (Kuo et al., 1999), of Chilka (Thomas and Ajmalkhan, 2003), of Ayiramthengu mangroves (Jisha et al., 2004) are documented. Silas (1987), Krishnamurthy and Jayasselan (1986) and Parulekar (1985) have drawn attention to the significance of aquaculture in the mangrove ecosystem of India. Mangrove areas serve as feeding, breeding and nursery grounds for many commercially important shell and fin fishes, in addition to providing shelter for the juvenile stages of these groups (Rajagopalan et al.1986; Robertson and Duke, 1987; Blaber and Milton, 1990; Morton, 1990; Laedsguard and Johnson, 1995). Moreover, juveniles emerge when the late larvae metamorphose and settle at the bottom and cling to the vegetation of submerged objects (Kurian and Sebastian, 1993). Mangrove vegetation offers a less disturbed habitat for fishes (Sheridan, 1992). Positive relationship observed between the phytoplankton and finfish and shrimps indicates that phytoplankton could be one of the major factors influencing the temporal fluctuation of fish juvenile population in mangrove biotopes (Chandrasekharan, 2000). Mangrove habitat in South Florida (Thayer et al., 1987) appears to support greater density and standing crop biomass of fishes than the adjacent fringing sea grass habitat. Several species utilizing mangroves are of commercial and recreational importance; many are forage foods for predatory fishes. A preliminary study on the fishery resources of the mangrove swamps of Sunderbans indicated that a rational and scientific exploitation of fish species, inhabiting the rivers and creeks has immense economic potentialities (Kalyan, 1978-79). Mangroves of Australia provide favourite fish habitats for about 197 fish species (Anon, 1997). Cecilia (1996) observed 73 species of fish from Muthupet mangroves and Kathiresan and David (1998) recorded 24 species of fishes from Australian mangroves.

The availability of fishes and their fry depend on the physico-chemical properties of the environment. Comparisons along physico-chemical gradients can be used to determine how species respond to features of their physical environment (Odum, 1982). Salinity is one of the factors that influence the metabolism of fish. Sahoo et al., (2003) inferred that salinity of 2ppt. is appropriate for the growth of fingerlings. Habitat segregation of fish is influenced by physicochemical properties of water, especially dissolved oxygen and availability of food organisms such as zooplankton and macro invertebrates (Muniyandi, 1985; Ajithkumar and Mittal, 1993 and Chandrasekaran and Natarajan, 1993). Positive correlation was observed in species richness of fish to water temperature in Maine (Lazzari et al., 1999) The fluctuation in salinity of Cochin backwaters is affected by the volume of the water discharged during the monsoon and water incursion during high tide, which plays a vital role in the development and distribution of organisms in the backwaters (Lalithambikadevi, 1993). Salinity and temperature were the significant factors, which determined distribution of fishes in the Kadinamkulam backwaters (De Silva and Silva, 1979). Rao (1970) studied the seasonal abundance of the larvae of *Chanos chanos* with reference to lunar phase, and observed positive correlation with time of the day and tide, surface salinity, surface temperature and rainfall. Basu and Pakrasi (1976) reported that the occurrence of fish larvae was correlated with the variation of salinity, temperature, clarity and velocity of water. Observations on the abundance and distribution of fishes in Queens land (Robertson and Duke, 1990), in Teacapon-Agua Brava (Flores et al.., 1990 and Pichavaram mangrove (Chandrasekaran and Natarajan, 1993) showed peak during post monsoon and pre monsoon season influenced by salinity and water temperature. The availability of fishes and their fry depend on the physico-chemical properties of the environment. Hence, the study on the seasonal variation of the physicochemical properties is essential to formulate the trend of availability of different fishes, as fishes respond to these gradients by movements to preferred zones or by adaptations to local salinity conditions in estuaries. Physiological tolerance of a wide range of salinities is a common adaptation in many species of estuarine fishes and many other behavioural adaptations such as dietary flexibility (Darnell, 1961; Beumer, 1978; Livingston, 1984; Laedsgaard and Johnson, 1995 and Kuo et al., 1999). Positive relation of ichthyofauna with salinity, temperature and transparency of Pulicat lake is reported (Rao, 1970). Patnaik and Misra (1990) studied the occurrence of *Chanos chanos* in relation to the surface temperature, transparency, salinity and pH of water of Rushikulya estuary. Observation on the effects of temperature on potential recruitment showed that spawning in the Chesapeake Bay is strongly influenced by temperature that were relatively warm, low river discharges and high, late season densities of zooplankton prey. Lorenz (1999) observed that fish density was found to be correlated primarily with hydro period and water level, presumably through greater recruitment during high water period. Biomass was also influenced by changes in salinity regime. Additionally these euryhaline fishes may display other behavioral adaptations such as dietary flexibility. Certain factors that superimpose on hydrology to influence species diversity are biogeography, size of estuarine zone, habitat diversity and openness to adjacent ecosystems (Baran et al., 1999 and Baran, 2000). Rainfall and organic content of sediments is responsible for the differences in fish abundance (Kuo et al., 1999).

Nature offers great diversity of food to fishes. A knowledge on the food and feeding is important in understanding its biology and therefore for a successful management of any fishery. Studies on the food preferences of few fishes of Gosthani estuary revealed that they exhibited food preferences according to their habitats. However, at times they were found to encroach upon other habitats, which might be due to the shallowness of the estuary

(Rao and Sivani, 1996a & b). Retting activity had a serious effect on fauna, in premonsoon period due to high temperature, which accelerates the process of disintegration of coconut husk producing hydrogen sulphide causing depletion of oxygen in the aquatic environment (Hynes, 1966; Metelev et al., 1983; and Bijoy and Abdul, 1993).

After the establishment of Ramsar convention in 1971, **bird** surveys have been conducted extensively. Much information has been documented on the field characteristics, status, distribution and general ecology of many species of Indian birds.

In the other parts of the world, a number of studies have been conducted on the distribution, migration and ecology of wetland birds. Kathiresan and David (1998) recorded 13 species of birds from Australian mangroves. The reef herons are observed on the coasts of West Africa and western coast of the Indian Ocean (Ripley, 1982).

Studies on Renuka wetland (Lalit et al., 2005) and Keoladaghana (Soni, 1990) showed migratory birds are choosing this wetland as new abode due to decreased rate of siltation. Studies from Gujarat by Naik and Parasharya, (1983) and Taej, (1985) provide information on change of natural nesting site by coastal birds due to habitat loss. Mahbal (2000) provided systematic list of 103 species from Renuka wetlands.

In Kerala, the Asian wetland bureau surveyed about 20% of wetland covering 20,000 ha and over 25,000 birds were recorded as a part of international waterfowl census (Joostvander, 1987). Ecological studies of birds of selected wetlands in Kozhikode and Malappuram districts (George, 1988; Ebrahimkutty, 1988; Ashraf, 1993; George, 2002 and Vijayakumar, 2006) recorded that these areas are suitable for birds. A study conducted by Nameer (1992 a, b) and Ravindran and Nameer (2001) of birds of Kole wetlands in Trichur shows that wetlands are attractive habitat of waterfowl.

Ali (1969) and Logan (1887) have documented a preliminary list of birds along wetlands of Kerala and Baker and Inglis (1930) have listed bird fauna of Malabar Coast. Subsequently many short notes on wetland birds were published (Namasivayam et al., 1987, 1989; Kurup, 1987; Uthaman et al., 1989; Shashikumar et al., 1989; Shashikumar, 1989, Andrew, 1990; Nameer, 1992; Srivastava et al., 1993; Jafer et al., 1997; Ravindran, 1999, 2001; Vijayakumar, 2006).

Altogether 249 species of birds are recorded from Periyar of which 60 species are new records for Periyar and three are new records for Kerala. Namasivayam et al., (1987) observed four species of birds- *Sterna sandvicensis, Pluvia squatarola, Calidris alpine, Calidiris temminki, flamantopus ostralegus* and *Larus fuscus* from mangrove ecosystem of Kadalundi, hitherto unrecorded in Kerala. *Ciconia nigra, C. ciconia, Treskionis arthiopica* and *Anastomus* (Kurup, 1987), *Rallus striatus*, and *Gallierex cinerea* Linn. (Neelakantan, 1989), *Pericrocotus divaricatus* (Andrew, 1990), *Phalacrocorax fuscicollis* (Sashikumar,1989) and records on observation of four endemic species like *Climator coromandus,* *Muscicapa subruba*, *Phylloscopus tytleri* and *Turdus obscurus* (Harrap and Redman, 1987) are few additions to the list of bird species of Kerala.

Reports on wetland birds recorded for the first time are *Pericrocotus divaricatus* (Andrew, 1990) from Periyar, *Mycteria leucocephala* from Kattampally (Sashikumar, 1985), *Anser indicus* (Krishnan,1985) and *Muscicapa parva* (Nitin,1985) from Point calimere and *Vanellus cinereus* from Peninsular India (Subramanya, 1985).

Sugathan et al., (1985) recorded eight new species from Point Calimere. Taej (1985) recorded *Chilidonias leucolterus*, from Gujarat. Reports from Karnataka include *Oriolus chinensis* (Banarjee, 1985), *Aegypius monachus* Linn. (Subramanya, 1999), *Sula dactylatra* (Madhyastha, 1985) etc. Varu and Bapat, (1987) and Himmat Singh, (1987) reported *Sula leucogaster* and *Ciconia ciconia* respectively from Western coast. Raol (1988) first recorded bar headed goose and Taej et al., (1989) snow goose from Gujarat.

Ramachandran and Vijayan (1994) and Mukherjee et al., (1992, 2001) observed that Sarus cranes are known to flock in wetlands to avoid heat stress. All waterfowls and swimming water birds are known to prefer large water bodies to avoid terrestrial predators by virtue of distance from shore (Weller et al., 1995). Pieter (1985) recommended Kaliveli wetland should be declared as bird sanctuary and effectively protected as he observed 86 species of birds both migratory and resident from this ecosystem.

The mangroves together with the extensive areas of sand flats provide a wide range of niches for avian species. Different workers like Osmaston (1905), Saha et al., (1971), Majumder et al., (1992), Chakraborthy (2005) have contributed to the knowledge of ornithology of mangrove ecosystem, which attracts large number of birds both in reclaimed areas and in mangrove forest. More than 300 species have been recorded earlier from mangrove areas in which a number of them are migratory (Choudhury and Choudhury, 1994). The large-scale destruction of mangroves for cattle fodder, firewood and timber resulted in the loss of the nesting habitat, so that the coastal birds have taken to nesting on trees in human settlements (Naik and Parasharya, 1983). The food and feeding habits of the reef herons in gulf of Khambat revealed that the food of adults and nestlings was mainly mud skippers picked from the mangrove swamps, shallow waters during flood or ebb tide (Naik and Parasharya, 1985).

After the tsunami struck different parts of the world, we realized the visible impact of anthropogenic pressures that have almost wiped out the mangrove vegetations. Few works in this context (Kar and Kar, 2005; Roy and Krishnan, 2005) proves that mangroves can check the wrath of sea intrusions.

RESULTS

RESULTS

CHAPTER - IV

RESULTS

Rapid and distinct seasonal changes of different environmental parameters are the striking feature of estuaries. A marked variation of all parameters and faunal abundance during different seasons was noticed at all the three sites.

In the year 2002-03 (Fig.1) site I recorded maximum **atmospheric temperature (AT)** in the month of May (36°c). The lowest temperature of 28°c was noted during monsoon season. During the year 2003-04 (Fig.2) a peak of 37°c was recorded during March and May and a decline in atmospheric temperature was noted during the Northeast monsoon in the month of October (27°c). In 2004-05 (Fig.3), highest temperature of 35°c was recorded during premonsoon and lowest of 29°c was observed during August. In 2005-06 (Fig.4), site recorded highest atmospheric temperature of 37°c during February – April and lowest of 27°c in September (Table: 1).

In the year 2002-03 (Fig.1) site II recorded maximum atmospheric temperature in the month of May (36°c). The lowest temperature of 26°c at site I was noted in the month of June. A maximum of 37°c during April–May and minimum of 27°c were noted in October during 2003-04 (Fig.2). In 2004-05, site II recorded maximum of 34°c in the month of March and a minimum of 29°c in the month of June (Fig.3). In 2005-06 (Fig.4), highest atmospheric temperature of 37°c was recorded during March – April and lowest of 27°c in September (Table: 1).

In the year 2002 (Fig.1), site III recorded highest atmospheric temperature of 35°c in the month of May. The lowest temperature of 26°c was noted during June. Maximum of 37°c during April–May and a minimum of 27°c were noted in October during 2003-04 (Fig.2). In 2004-05 (Fig.3), this site showed maximum of 34°c in the month of March and a minimum of 28°c in the month of August. During 2005-06 (Fig.4), maximum of 38°c was noted during March and a minimum of 27°c in September (Table: 1).

Results of ANOVA analysis indicated that AT varied significantly between season from 2002 to 2006 in all the three sites ($p < 0.05$) (Table: 16-18).

The **temperature at the sea-surface** (SST) (Table: 2) in site I during the first year (2002-03) showed maximum temperature of 36°c in the month of April and minimum of 27°c in July and September (Fig. 5). In the year 2003-04 (Fig.6) site recorded highest temperature during March–May (34°c) and lowest in August (27°c). During the year 2004-05 (Fig.7) highest temperature was in May (33°c) and lowest temperature of 28°c in the month of August. In the year 2005-06 (Fig. 8) 35°c was the maximum temperature at this site (February) and 27°c (August) was the lowest temperature. From 2002 to 06, significant difference was observed in SST across different seasons ($p < 0.05$) (Table: 19).

The SST (Table: 2) at site II during 2002-03 (Fig.5) showed maximum temperature of 36°c in the month of April and a minimum temperature of 26°c in September. In the year 2003-04 (Fig.6) April and May showed peak temperature of 34°c and it declined to 27°c during June – September. During the year 2004-05 (Fig.7) highest temperature of 31°c was in April and lowest of 27°c during June and August. While in the year 2005-06 (Fig.8), 35°c was the maximum temperature recorded in February and 27°c was the lowest temperature (July –August). No significant seasonal difference in SST was observed during 2002-03. Following years (2003-06) showed significant seasonal variations in SST (Table: 20).

In site III, SST during 2002-03 showed maximum temperature of 34°c during April – May (Fig.5) and a minimum temperature of 26°c in September. In the year 2003-04 (Fig.6), peak temperature of 34°c was observed in April and May and the lowest of 27°c was recorded from June – September. During the year 2004-05, SST was in April (32°c) and lowest recorded was 27°c during June- August (Fig.7). In the year 2005-06 (Fig.8), 35°c (February) was the maximum temperature and 27°c was the lowest temperature (July –August) (Table: 2). Results of ANOVA indicated that SST (Table: 21) varied significantly seasonally from 2002 to 2006.

At site I **dipped water temperature** (DWT) during 2002-03 (Fig. 9) was maximum in April (33°c) and minimum in July and September (26°c). In 2003-04 (Fig.10) the site recorded maximum DWT of 34 °c in May and minimum of 27°c in September. During the year 2004-05 (Fig.11), site I showed maximum DWT in April (34°c) and minimum of 27°c in June. During 2005-06 (Fig.12) DWT was maximum (34°c) in the month of May and minimum of 27°c in September (Table: 3). DWT (Table: 22) varied significantly between seasons except in 2005-06 (p = 0.0827).

DWT at site II during 2002-03 (Fig.9) was 31°c throughout the premonsoon period and was lowest during July to September (26°c). In 2003-04 (Fig.10) March – May recorded highest DWT of 32°c and lowest temperature of 26°c was observed in July. During the year 2004-05 (Fig.11), February and April (30 °c) showed the maximum DWT and August recorded the minimum DWT (26°c). During 2005-06 (Fig.12), DWT peaked from April - May (32°c) and was lowest in July (26°c) (Table: 3). DWT (Table: 23) varied significantly between seasons except in 2004-05 (p = 0.429260).

In site III, DWT during 2002-03 (Fig.9) was a maximum of 31°c throughout the premonsoon season and minimum of 26 °c during July to September. In 2003-04, maximum DWT of 32 °c was noted during April-May and minimum of 26°c in July (Fig.10). In the year 2004-05 (Fig.11), DWT was maximum in February and April (30 °c) and minimum of 26°c during August. During 2005-06 (Fig.12), site III recorded peak DWT in April (32°c) and minimum in July (26°c) (Table: 3). DWT (Table: 24) was not significantly different between seasons during 2004-05 (p =0.439466).

At site I, the **dissolved oxygen** (DO) content in the surface waters was highest during monsoon. In 2002-03 (Fig.13) oxygen content showed a maximum of 7.772 ml/l. (August). It was reduced to 4.144 ml/l. in April and May. During 2003-04 (Fig.14), site I recorded maximum DO content in August (5.97 ml/l) and minimum in March to April (3.6 ml/l). DO content during 2004-05 (Fig.15) was highest in the month of August 7.56 ml/l and reduced to 3.40 ml/l in March. In 2005-06 (Fig.16), peak concentration observed was 5.92 ml/l in August and lowest 3.208 ml/l in April (Table: 4). DO (Table: 25) content varied significantly between seasons throughout the study period ($p< 0.05$).

In 2002-03 (Fig.13) DO content showed a maximum of 5.92ml/l. (September) at site II, with a minimum 3.4 ml/l. in March. During 2003-04, maximum DO content was recorded in September (5.8 ml/l) and minimum was recorded in April (3.256 ml/l.) (Fig.14). DO during 2004-05 (Fig.15) was highest in the month of August (6.36 ml/l) and reduced to 2.96 ml/l (March). In 2005-06 (Fig.16) peak concentration observed was 5.92 ml/l (August) and lowest 3.20 ml/l in April. (Table: 4). Seasonal variation in DO varied significantly ($p < 0.05$) (Table: 26).

In 2002-03 (Fig.13) DO at site III showed a maximum of 5.92ml/l in September and it was reduced to 3.7 ml/l. in April. During 2003-04 (Fig.14), site showed a maximum in August (5.77 ml/l) and minimum was recorded in April (3.11 ml/l). DO during 2004-05 (Fig.15) was highest (6.28 ml/l) in the month of August and reduced to 3.40 ml/l (April). In 2005-06 (Fig.16) peak concentration observed was 5.86 ml/l in September and 3.2 ml/l in April (Table: 4). DO (Table: 27) varied significantly seasonally from 2002 to 2006 ($p < 0.05$).

At site I, during 2002-03 (Fig.17) phosphate content showed a maximum of 1.7µg/l in July. It was reduced to 0.4µg/l, in March. During 2003-04 (Fig.18), maximum phosphate content was recorded in June (1.2 µg/l) and minimum in March (0.22µg/l). Maximum phosphate content during 2004-05 (Fig.19) was 1.5µg/l in the month of June and July and it was reduced to 0.35µg/l in March and May. In 2005-06 (Fig.20) peak concentration was observed in June (1.95µg/l). Lowest phosphate content of 0.22 µg/l was recorded in April (Table: 5). Phosphates (Table: 28) differed significantly ($p < 0.05$) between seasons from 2002-06.

In 2002-03 (Fig.17) phosphate content showed a maximum of 1.25µg/l (August) at site II. It was reduced to 0.22µg/l in March. During 2003-04 (Fig.18), month of June recorded highest content (1.19µg/l) and minimum of 0.19 µg/l was recorded in March. Maximum phosphate content during 2004-05 (Fig.19) at site II was during June (1.25µg/l). It was reduced to 0.18µg/l in February. In 2005-06 (Fig.20) peak concentration was observed in June (1.25µg/l). Lowest phosphate content 0.22µg/l was recorded in February (Table: 5). Phosphates showed significant seasonal variation ($p< 0.05$) from 2002-06 (Table: 29).

During 2002-03, phosphate content at site III showed a maximum of 1.2 µg/l (August). It was reduced to 0.28µg/l in March (Fig.17). During

2003-04 (Fig.18), maximum of 1.19μg/l was noted in June. Minimum phosphate content of 0.19μg/l was recorded in March and April. Maximum phosphate content during 2004-05 (Fig.19), at site III was during June (1.4μg/l). It was reduced to 0.25 in February. In 2005-06 (Fig.20) peak concentration was observed in June (1.82μg/l). Lowest phosphate content of 0.39μg/l was recorded in February (Table: 5). During 2003-04 (Table: 30), seasonal variation in phosphate concentration was insignificant ($p = 0.436414$) while it was significant ($p < 0.05$) for the 3 other years.

Free carbon dioxide (FCO_2) during the year 2002-03 (Fig.21) was highest (2.6 ml/l) from February to March and minimum (0.3 ml/l) in September. In 2003-04 (Fig.22), May and June recorded maximum concentration of 2.6 ml/l, while minimum value was 0.3 ml/l (October). In 2004-05 (Fig.23), the month of April recorded the maximum carbondioxide content (2.8 ml/l) and June –July recorded the lowest content (0.5 ml/l). Again after an increase in August, a decline is noted during the north east monsoon. During 2005-06 (Fig.24), FCO_2 content was higher in February and March (2.8 ml/l) and lower in August (0.3 ml/l) (Table: 6). Distinct pattern of seasonal variation was not seen in FCO_2 (Table: 31) value during 2003-04 ($p = 0.088$) while significant difference was observed in other years ($p < 0.05$).

FCO_2 recorded at site II during the year 2002-03 (Fig.21) was highest from February to March (2.5ml/l) and throughout the monsoon season it was a minimum of 0.5 ml/l. In 2003-04 (Fig.22), May and June recorded maximum concentration of (2ml/l), while minimum value was 0.25 ml/l (November). During 2004-05 (Fig.23), month of April recorded the maximum FCO_2 content in site II (2.75 ml/l), while the month of June – July recorded the lowest content (0.5 ml/l). During 2005-06 (Fig.24), FCO_2 content was higher in March (2.5 ml/l,) and lower in August (0.25 ml/l) (Table: 6). FCO_2 (Table: 32) values were significantly different across the seasons during all the year except in 2003-04 ($p= 0.173272$).

At site III FCO_2 during the year 2002-03 (Fig.21) was highest in the month of March (2.5ml/l) and lowest of 0.5 ml/l from June to October. In 2003-04 (Fig.22), maximum concentration was recorded from May to June (2ml/l), while minimum was 0.5ml/l (August to October). In 2004-05 (Fig.23), the month of April showed maximum concentration (2.5 ml/l) during March – April. Site III showed minimum concentration of FCO_2 throughout the monsoon season (0.45 ml/l). During 2005-06 (Fig.24), FCO_2content was higher in March (2.45 ml/l) and lower in August (0.32 ml/l) (Table: 6). Seasonal variation during 2003-04 (Table: 33) was insignificant ($p =0.163555$). All other years showed significant difference in FCO_2 content ($p< 0.05$).

Hydrogen ion concentration (pH) fluctuated slightly throughout the year except during monsoon. In 2002-03 (Fig.25), the pH value was high during September to October (9) and lowest in the month of April and May (7.8). During 2003-04 (Fig.26) the estuarine water recorded highest value of

9 (September and October) and lowest value was recorded in June (7). In the year 2004-05 (Fig.27), site I recorded highest value in August (9) and lowest value was 7 from June to September. During the year 2005-06 (Fig.28) highest value of 8.5 was recorded from January to April and also from December to January. Lowest value was in August (7) (Table: 7). Variation of pH (Table:34) values were negligible ($p > 0.05$) during the first two years (2002-04), while following two years (2004-06) showed significant difference ($p < 0.05$).

In 2002-03 (Fig.25), the pH value was high during October (8.51) and lowest in the month of February (7.31) in site II. During 2003-04 (Fig.26) the estuarine water recorded highest value of 8.5 (September to October), while lowest value was recorded in June (7). In the year 2004-05 (Fig.27), site II recorded the highest value (8.5) in October after a decline it again increased during January and February and lowest value of 7 was recorded from July - September. During the year 2005-06 (Fig.28) highest value recorded was 8 in May and lowest value of 7 was in August and October (Table: 7). Values of pH were not significantly different during 2002-04 ($p = 0.236104$ and 0.376924 respectively). At the same time it showed significant seasonal variation ($p < 0.05$) from 2004-06 (Table: 35).

Hydrogen ion concentration remained almost the same with minor fluctuation throughout the year. In 2002-03 (Fig.25), the pH value of 8 was observed in August and minimum 7.35 in April. During 2003-04 the estuarine water recorded a pH of 8 in August. Lowest value was recorded in June (7.3) (Fig.26). In the year 2004-05 (Fig.27), maximum was recorded in June (8.62) and lowest value was 7 (September). During the year 2005-06 (Fig.28), peak of 7.72 was in June and May and July recorded lowest value of 7 (Table: 7). Values of pH were not significantly different during 2002-06 ($p > 0.0$).

The **salinity** was highest during premonsoon months, which was inversely proportional to precipitation. In all the three sites generally salinity was observed to increase from November after the monsoon and reached its maximum around March – May. Salinity was observed for three years, February 2003 to January 2006. In 2003-04 (Fig.29) salinity was high from April to May (18°/₀₀), while least amount was seen during monsoon season (June and August 8.25°/₀₀) after a decline it again increased to 16.4°/₀₀ by May during 2004-05 (Fig.30) and decreased to 8 °/₀₀ by July. During 2005-06 (Fig.31) maximum salinity was seen in the month of May (18.8°/₀₀) and minimum in July (7°/₀₀) (Table: 8). Salinity (Table: 37) values were significantly different between seasons ($p < 0.05$).

Salinity at site II during 2003-04 (Fig.29) was high in March to April (15.5°/₀₀), while least amount was seen during monsoon season (June = 8.1 °/₀₀). During 2004-05 (Fig.30) it was elevated to 16.1°/₀₀ by May and decreased to 7.5°/₀₀ by July. In 2005-06 (Fig.31) maximum salinity was seen in the month of April (18°/₀₀) and minimum in July (7°/₀₀) (Table: 8). Salinity (Table: 38) was not significantly different during 2004-05 ($p = 0.425831$) and 2005-06 ($p = 0.06$).

During 2003-04 (Fig.29) site III recorded the highest salinity ($18^{o}/_{oo}$) during the month of May and minimum was recorded in the month of July ($7.7^{o}/_{oo}$). In 2004-05 (Fig.30) highest salinity was seen in the month of May (15.3 ppt.) and lowest in July ($7.8^{o}/_{oo}$). In 2005-06 (Fig.31), the maximum of 18 ‰ was recorded in the month of April and June recorded minimum salinity (7‰) (Table: 8). Salinity (Table: 39) was not significantly different between seasons during 2004-05 ($p = 0.716226$).

Analysis of spatial variation showed no significant difference across the sites (Table: 40-47). Simple correlation was done to determine if any environmental parameters were related (linear relationships) with each other. A positive correlation was observed between temperature, free carbondioxide and salinity and inversely correlated with dissolved oxygen, phosphates and pH during 2002-04 in all the three sites. During 2004-06, pH showed positive correlation with temperature, free carbondioxide and salinity in site I and II. Similar correlation was seen in site III during 2004-05 (Table: 48-59).

Observations made and recorded pertaining to the **faunal** associates (Table: 9-15, Plate: 2-20) of mangrove systems in three sites (two sites of Kadalundi and a site from Nalallam) of northern Kerala are detailed below. Three distinct types of organisms were found here namely the exclusive mangrove residents, the marine species and fresh water species, the last two are frequent visitors to the mangrove ecosystem.

Forty three species of **zooplanktons** (Table: 9; Plate: 2-3) were recorded from the three sites. Of these 42 species were collected from site I, 26 species from site II and 27 species from site III. Ten species common to the three sites were counted for population studies.

The population densities of the different species from all the three sites are given in Table: 60-65. Among zooplanktons *Acartia major* was the dominant species throughout the study in all the three sites. ANOVA of site I shows that species like *Meretrix meretrix* and *Telescopium telescopium* (p = 0.1235 and 0.227537 respectively) showed no significant seasonal variation during 2004-05. While, *Acartia major, A.gracillis, Scylla serrata, Penaeus indicus, Metapenaeus dobsoni and Tanais philetaerus* was significantly different during 2005-06 (p = 0.009725, 0.011989, 0.057915, *0.210883*, 0.946327 and 0.01335 respectively). There was no significant difference in the population density of species like *A.major* and *O.bravicornis* (p = 0.062786 and 0.320243 respectively) across the season during 2004-05 at site II. While *A. gracilis, C anthocalanus pauper, Diaptomus parvus, Paracalanus parvus, Pseudodiaptomus aurivelli, Lucifer hanseni, Penaeus indicus and Sagitta enflatta* was significantly different during 2005-06 (p = < 0.05). During 2004-05 in site III, seasonal variation was insignificant among *Mesocyclops leuckarti, Oithona similis, T. philetaerus, L.hanseni, Metapenaeus dobsoni, S. enflatta and Sesarma lanatum* (p = 0.146, 0.157, 0.72, 0.076, 0.57, 0.17, 0.076, 0.32 and 0.22 respectively). In 2005-06, *D.parvus, P. parvus, P. aurivelli, M. leuckarti, Euterpina alcifrons* and *T. philetaerus* (p = 0.033, 0.059, 0.022, 0.043, 0.045 and 0.0039 respectively) significantly varied between seasons (Table: 78 – 80).

Correlation analysis of zooplanktons with physico-chemical parameters from all the three sites are given in Table: 87-92. Site I and site II showed a similar pattern throughout the study. During 2004-05, Calanoids, Cyclopoids, Harpacticoids, Decapods and Chetognaths showed positive correlation with temperatures, pH and salinity, while during 2005-06 they showed negative correlation with temperatures, pH and salinity, but were positively correlated with dissolved oxygen and phosphates. *T. philetaerus* showed positive correlation with dissolved oxygen and phosphates and negative correlation with temperatures, pH and salinity throughout the study period. In the site II *T.philetaerus* was totally absent in premonsoon season. But in site III, Calanoids, Cyclopoids, Harpacticoids, Decapods and Chetognaths exhibited positive correlation with temperature, dissolved oxygen, pH and salinity during 2004-06.

Prawns were observed for two years (2004-06). A total of five species were collected during the study. They are *Penaeus indicus, P.monodon, Metapenaeus dobsoni, Metapenaeus monocerous and Macrobrachium rosenbergii* (Table: 10; Plate : 7). Of these all species were collected from site I and site III and three species (*P.indicus and M.dobsoni and M.monocerous*) from site II. *Penaeus indicus and*

M.dobsoni were the most abundant species during the period of the present study. Prawns followed a bimodal distribution with peaks during premonsoon and post monsoon.

Crabs were collected during February 2004 to January 2006 for population studies. A total of 16 species were collected during the study. Of these fifteen species were collected from site I, four species from site II and six species from site III (Table: 11; Plate: 4). *Uca lactea* was abundant in the mangrove estuarine environment. Species like *Scylla serrata* were observed occupying the mud banks.

In the first year (2004-05), 2595 crabs were collected from site I. *Uca lactea* was the dominant species followed by *Uca acuta* during all the three seasons. Species like *Dotilla intermedia, Sesarma taeniolata, S. lenatum and S.granulata* were totally absent in the monsoon season. During the post-monsoon period, species like *D. myctiroides, D. intermedia* and *S. lenatum* were absent (Table: 66). During 2005-06, 2108 crabs were collected from site I. In the premonsoon and post-monsoon season *U. lactea* was the dominant species followed by *Scylla serrata. U.lactea* was the dominant species during monsoon season followed by *Gelasimus annulipes* (Table: 67).

Significant population density across the seasons was observed in *C. lucifer, S. taeniolata, U. acuta acuta and U. lactea* during 2004-05 (p = 0.029, 0.0009, 0.0001 and 0.00045 respectively). While in the year 2005-06 *D. myctiroides, S. granulata, S. serrata* and *S. taeniolata* showed no significant seasonal variation ($p > 0.05$). Potunids, Ocypodids and Grapsids showed positive correlation with temperature and salinity during 2004-06 (Table: 78).

In site II during 2004-05, 1435 crabs were collected. *Uca lactea* was the dominant species followed by *S. serrata* during pre-monsoon and post-monsoon seasons. During the monsoon period, 37 crabs were collected. *S.serrata* was the dominant species followed by *U. lactea*. *U. acuta* was absent during monsoon and post monsoon season (Table: 68). During 2005-06 (site II), 818 crabs were collected. *U. acuta* was the leading species in the collection followed by *S. serrata* in premonsoon and post monsoon seasons. While both species were absent in monsoon collection (Table: 69).

Sesarma taeniolata showed significant difference in their population density across the seasons ($p = 0.003214$) during 2004-05. In the second year (2005-06) *S. taeniolata* and *U .lactea* showed seasonal variation ($p = 0.005603$ and 1.65 E-05). All species showed positive correlation with temperature and salinity and an inverse relation was observed with dissolved oxygen, phosphate and pH during 2004-06 (Table: 79).

In the first year (2004), 1254 crabs were collected from site III. The *U. lactea* was the dominant species followed by *U. acuta* in all the three seasons. Species like *D. myctiroides* and *S.taeniolata* were totally absent in the monsoon season. *Unlike in other sites Portunus pelagicus was* *present in this season* from site III (Table: 70). During 2005-06, 1039 crabs were collected. *U. lactea* was the leading species followed by *U.acuta* in all the three seasons (Table: 71).

Population density of *D. myctiroides* differed significantly across the seasons, during 2004-05 (p =1.11E-05). While in the year 2005-06, all species exhibited seasonal variation ($p < 0.05$). All species except *P. pelagicus* showed positive correlation with temperature and salinity and an inverse relation was observed with dissolved oxygen, phosphate and pH during 2004-06. *P. pelagicus* which was collected in monsoon showed positive correlation with dissolved oxygen, phosphate and pH throughout the study period (Table: 83).

Distribution of **molluscs** was generally patchy. Thirty four species were collected during the study (Table: 12, Plate: 5&6). Of these 33 species were collected from site I, 10 species from site II and 8 species from site III.

The species *Neritina violacea* was the common gastropod species found in estuaries and backwaters. Two species *Littorina melanostoma* and *L. scarba* were often found attached to stems and leaves of *Rhizophora* species. *Turittela. attenuata* were found buried in the sandy and *L. scarba* were often found attached to stems and leaves of *Rhizophora* species. *Turittela. attenuata* were found buried in the sandy bottoms close to the estuarine mouth. *Cerithidea cingulata* and *Telescopium telescopium* were the dominant groups of sand flats. The fresh water species *Pila globossa* was observed to occur in considerable abundance in the mangrove wetlands of site II and site III during the monsoon and early post monsoon (in October). Species like *Anadra granosa* and *Meretrix meretrix*, were seen in the mud banks forming large beds of their shell deposits.

In the pre-monsoon period in 2004-05, (Table: 34) from site I, 1062 molluscs were collected. The *T.telescopium* was the dominant species followed by *M.meretrix*. *M.ovum*, *Crassotrea madrasensis and Murex tribulus* was totally absent in this season. During monsoon period, 102 molluscs were collected of which *C.obtusa* was the leading species followed by *C. cingulata* and *Bursa granulata*. All other species were totally absent. Throughout the post-monsoon period, out of 1731 molluscs collected, *T. telescopium* was the primary species followed by *N. violacea*. In 2005-06 (Table: 35), 700 and 894 molluscs were collected from site I during premonsoon and post monsoon seasons respectively. *C. obtusa* was the leading species followed by *C. cingulata* correspondingly in both the seasons. Out of 102 molluscs collected in monsoon season, *T. telescopium* dominated the collection followed by *T. attenuata*.

During 2004-05 species like *C.obtusa* and *Harpa conoidalis* and during 2005-06, *C. obtusa, Oliva gibbosa, T. attenuata* and *T. duplicata* showed no remarkable seasonal variation ($p > 0.05$).

The population density of different molluscan species collected from site II are given in Table: 12. The *N. violacea* was the dominant species throughout the study except in the monsoon season during 2005-06. *P. globossa* was the dominant species in the monsoon season, while few species like *C. madrasensis*, *M. meretrix* and *O. gibbosa* were totally absent in monsoon season (Table: 37).

During 2004-05 species like *C. cingulata*, *C. obtusa*, *C. madrasensis*, *L. melanostoma* and *M. ovum* ($P > 0.05$) showed no significant difference across the seasons. While in the second year insignificant variation across the seasons was observed in *C .cingulata*, *C. madrasensis* and *N. violacea* ($p = 1.68$, 0.33 and 0.44 respectively).

From site III, 440 (2004-05) and 541 (2005-06) molluscs respectively were collected. *L. melanostoma* was the dominant species followed by *L. scarba* in the premonsoon and post monsoon seasons. *P. globossa* was the dominant species in the monsoon season during both years (Table: I. 31-32).

Among molluscan fauna seasonality was not observed among *M. meretrix* and *T. brenneus* ($p = 0.289$ and 0.218 respectively) during 2004-05. During 2005-06 all species exhibited seasonality ($p < 0.05$). Correlation analysis of site I showed that except *B. granulosa* all species exhibited positive correlation with atmospheric, surface water and dipped water temperatures, pH and salinity during 2004-05. In the next year all species showed positive correlation with atmospheric, surface water and dipped water temperatures, pH and salinity and inverse relationship with dissolved oxygen and phosphates.

Correlation analysis of site II and III showed that except *P. globosa* all species exhibited positive correlation with atmospheric, surface water and dipped water temperatures, pH and salinity throughout the study period (2004-06). While *P. globosa* which was observed only in monsoon showed positive correlation to dissolved oxygen and phosphates.

Seasonal variation in diversity showed that fauna of (zooplanktons, crabs and molluscs) all three study sites exhibited a bimodal distribution with peaks during premonsoon and post monsoon seasons. Comparative study of population density of zooplankton was higher in site I followed by site III and minimum in site II, diversity values were at maximum in site II followed by site I and site III. Crabs diversity was higher at site I followed by site III and minimum at site II. While superior molluscan diversity was observed in site I followed by site II and site III bared minimum.

Fishes are the conspicuous component of mangrove estuarine ecosystem with large numbers invading the mangrove forest at high tide and retreating to deep waters as tide fall. In the present faunal survey, as many as 64 species was collected (Table: 13, Plate :). Of these 52 species were collected from site I, 29 species from site II and 41 species from site III. The ichthyofaunal diversity recorded was maximum at site I followed by site III and site II. This spectrum of diversity included a number of species of marine fishes exhibiting notable preference or affinity to occupy the mangrove-estuarine and backwaters for feeding and breeding purposes. The major group of fishes observed in the present study belonged to the gobiid family (6 species). Semi-anadromous fishes like Epinaphales species spawns in the coastal tidal fresh water marsh as well as oligohaline mangrove marsh waters. Juveniles remained in the mangrove marsh edges. Stone fish which is not a common fish of mangrove ecosystem but reef associated was also collected from site III.

The mangrove systems were found to have a bevy of activities by **insects** such as hymenopterans, lepidopterans and odonates, notably during lush green phase of growth followed by the flowering phase of mangrove floras. 153 species of insects were collected during the present study with Hymenopterans dominating. This abundance of hymenopterans was mainly contributed by Formicidae. 24 species of odonates were collected during the present study. The orthopterans were seen feeding in the mangrove canopy. Coleopterans comprised predominantly of insect pests infesting the floral components. Some weevils have been observed from mangrove seed capsules. The ant fauna were diverse. Most of them were arboreal and few species were found nesting in hollow twigs. Three species of mosquitoes observed during the present study were Aedes species, Culex sitiens, and Culex quinquefasciatus. The list of insect species is given in Table: 14 (Plate :).

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 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, and shore birds. Mangrove- estuarine habitat was found to have a diversity of about eighty two species, 79 in site I, 36 in site II and 26 in site III (Table: 15; Plate:). The maximum avian diversity was found at site I. The shore birds were mostly migrants commonly called as waders and included sandpipers, Plovers, Snipe, Sanderlings, Stint, Whimbrel etc. While the water birds include, resident, local and distant migrants. The water bird category among the avian visitors at the estuary included the resident and local migrants like pond heron, cattle egret, median egret, large egret, water hen, little egret and the distant migrants such as the reef heron, grey heron, white ibis etc. The sea birds were terns and gulls having their population distribution in all the three study sites. Large flock, 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 polychaete worms, crustaceans and small fishes. In all the three sites the maximum number was observed during the onward migration. The birds began arriving by the first week of September and there after showed a declining trend. The most spectacular sight to a casual visitor of Kadalundi is the flight of gulls and terns which are usually present in thousands. Generally the gulls and terns used the sand flats of the estuary as resting places during the hot hours of the day.

Table: 1. Atmospheric temperature (° c) of three sites from 2002-06													
Months	**Sites**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
2002-03	**Site I**	30	34	35	36	28	28	28	28	28	30	29	28
	Site II	30	34	35	36	26	28	28	27	27	30	29	28
	Site III	30	34	34	35	26	28	28	27	27	30	29	28
2003-04	**Site I**	34	37	37	37	32	29	28	29	27	32	34	32
	Site II	34	36	37	37	32	28	28	28	27	32	33	32
	Site III	34	36	37	37	32	28	28	28	27	32	33	28
2004-05	**Site I**	34	34	35	35	30	30	29	30	32	32	34	32
	Site II	32	34	33	30	29	30	28	30	32	32	32	32
	Site III	32	34	33	30	29	29	28	30	30	32	32	32
2005-06	**Site I**	37	37	37	32	29	28	29	27	32	34	37	34
	Site II	36	37	37	32	28	28	28	27	32	33	37	34
	Site III	34	38	37	32	28	28	28	27	32	33	37	34

Table: 2. Surface water temperature (°c) of three sites from 2002-06													
Months	**Sites**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
2002-03	**Site I**	32	33	36	34	32	27	29	27	33	32	30	32
	Site II	32	33	36	34	30	27	27	26	20	32	30	32
	Site III	32	32	34	34	27	27	27	26	29	32	30	30
2003-04	**Site I**	33	34	34	34	30	32	27	29	30	31	32	33
	Site II	32	32	34	34	28	27	27	28	28	31	32	33
	Site III	32	32	34	34	28	27	27	27	28	31	30	30
2004-05	**Site I**	30	30	32	33	29	29	28	29	31	31	32	32
	Site II	30	28	31	29	27	28	27	29	31	31	33	30
	Site III	30	28	32	29	27	27	27	29	31	31	34	30
2005-06	**Site I**	35	34	34	34	30	32	27	29	30	31	32	32
	Site II	35	32	34	34	28	27	27	28	28	31	32	32
	Site III	35	32	34	34	28	27	27	27	28	31	30	32

Table: 3. Dipped water temperature (° c) of three sites from 2002-05

Months	Sites	Feb	Mar	Ap	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
2002-03	Site I	31	32	33	32	30	26	27	26	30	31	28	31
	Site II	31	31	31	31	29	26	26	26	28	31	27	31
	SiteI	31	31	31	31	28	26	26	26	28	31	27	31
2003-04	Site I	31	33	32	34	29	31	28	27	31	30	30	32
	Site II	30	32	32	32	27	26	27	27	27	30	29	31
	Site III	30	32	32	31	27	26	27	27	27	30	29	28
2004-05	Site I	30	30	34	31	27	29	28	28	30	30	31	31
	Site II	30	28	30	27	27	27	26	28	24	30	30	31
	Site III	30	28	30	27	27	27	26	28	24	30	30	30
2005-06	Site I	30	30	32	34	29	31	28	27	31	30	30	30
	Site II	30	30	32	32	27	26	27	27	27	30	29	30
	Site III	30	30	32	31	27	26	27	27	27	30	29	30

Table: 4. Dissolved oxygen content (ml/l) of three sites from 2002-06													
Months	**Sites**	**Fe**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
2002-03	**siteI**	4.8	4.4	4.14	4.14	5.18	5.9	7.77	6.66	5.03	3.55	4.82	4.8
	siteII	4.4	3.4	3.8	4.3	4.86	5.1	5.47	5.92	4.98	3.5	4.8	4.44
	siteIII	4.4	4.44	3.6	4.4	4.73	5.7	5.77	5.92	4.44	4.44	4.8	4.59
2003-04	**siteI**	4.8	3.6	3.6	3.84	5.84	5.7	5.97	5.92	5.8	4.78	4.7	5.6
	siteII	4.1	3.54	3.25	3.40	5.18	5.6	5.7	5.8	4.93	4.73	4.44	4.14
	siteIII	4.2	3.84	3.10	3.40	5.32	5.7	5.77	5.72	4.88	4.73	4.44	4.53
2004-05	**siteI**	4.7	3.40	3.70	4.5	5.5	5.8	7.56	5.92	5.77	5.42	4.75	4.49
	siteII	4.1	2.96	3.70	4.44	5.18	5.7	6.36	5.92	5.62	5.38	4.73	4.44
	siteIII	4.2	4.14	3.40	4.03	5.18	5.1	6.28	5.03	6.21	4.73	4.78	4.58
2005-06	**siteI**	4.2	3.84	3.20	3.40	5.32	5.7	5.92	4.88	4.73	4.44	4.44	4.29
	siteII	4.1	3.84	3.20	3.40	5.32	5.7	5.92	4.88	4.73	4.44	4.44	4.14
	siteIII	4.1	3.82	3.2	3.33	5.22	5.6	5.62	5.86	4.66	4.4	4.38	4.28

Table: 5. Phosphate (μg/l) of three sites from 2002-06													
Months	**Sites**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
2002-03	**siteI**	**0.48**	**0.4**	**0.55**	**0.48**	**0.7**	**1.7**	**1.5**	**0.82**	**0.75**	**0.7**	**0.65**	**0.5**
	siteII	**0.47**	**0.22**	**0.59**	**0.48**	**0.65**	**0.74**	**1.25**	**0.8**	**0.68**	**0.59**	**0.55**	**0.22**
	siteIII	**0.4**	**0.28**	**0.55**	**0.48**	**0.7**	**1.05**	**1.2**	**0.65**	**0.65**	**0.58**	**0.45**	**0.36**
2003-04	**siteI**	**0.4**	**0.22**	**0.25**	**0.5**	**1.2**	**0.75**	**0.7**	**0.75**	**0.58**	**0.55**	**0.55**	**0.45**
	siteII	**0.39**	**0.19**	**0.23**	**0.47**	**1.19**	**0.7**	**0.62**	**0.6**	**0.45**	**0.4**	**0.5**	**0.4**
	siteIII	**0.35**	**0.27**	**0.19**	**1.37**	**1.03**	**0.75**	**0.68**	**0.66**	**0.57**	**0.52**	**0.43**	**0.36**
2004-05	**siteI**	**0.4**	**0.35**	**0.55**	**0.35**	**1.5**	**1.5**	**0.85**	**0.85**	**0.75**	**0.6**	**0.6**	**0.55**
	siteII	**0.35**	**0.18**	**0.55**	**0.28**	**1**	**1.25**	**0.78**	**0.82**	**0.68**	**0.55**	**0.6**	**0.4**
	siteIII	**0.25**	**0.4**	**0.57**	**0.69**	**1.4**	**0.98**	**0.78**	**0.88**	**0.76**	**0.7**	**0.69**	**0.54**
2005-06	**siteI**	**0.5**	**0.45**	**0.22**	**0.5**	**1.95**	**0.85**	**0.98**	**1**	**0.75**	**0.6**	**0.6**	**0.55**
	siteII	**0.44**	**0.32**	**0.22**	**0.48**	**1.25**	**0.74**	**0.83**	**0.88**	**0.6**	**0.58**	**0.6**	**0.48**
	siteIII	**0.25**	**0.39**	**0.56**	**0.49**	**1.82**	**0.75**	**1.04**	**0.92**	**0.66**	**0.49**	**0.64**	**0.46**

Table: 6. Free carbondioxide (ml/l)of three sites from 2002-06													
Months	**Sites**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
2002-03	**siteI**	**2.6**	**2.6**	**2.4**	**1.5**	**0.6**	**0.5**	**0.4**	**0.3**	**0.5**	**1.5**	**1.7**	**0.6**
	siteII	**2.5**	**2.5**	**2**	**1.5**	**0.5**	**0.5**	**0.5**	**0.3**	**0.5**	**1.45**	**1.5**	**0.5**
	siteIII	**2.5**	**2.5**	**2**	**1**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**1.25**	**1.5**	**0.5**
2003-04	**siteI**	**1.8**	**1.8**	**1.5**	**2.6**	**2.6**	**1.5**	**0.8**	**0.6**	**0.3**	**0.5**	**0.6**	**0.6**
	siteII	**1.5**	**1.5**	**1.5**	**2.5**	**2.5**	**1.5**	**0.5**	**0.5**	**0.3**	**0.5**	**0.5**	**0.6**
	siteIII	**1.5**	**1.5**	**1**	**2**	**2**	**1**	**0.5**	**0.5**	**0.5**	**0.25**	**0.5**	**0.5**
2004-05	**siteI**	**2.5**	**2.5**	**2.8**	**1.9**	**0.5**	**0.5**	**1**	**0.5**	**0.5**	**0.6**	**0.55**	**1.5**
	siteII	**2**	**2**	**2.75**	**1.55**	**0.45**	**0.5**	**0.85**	**0.45**	**0.5**	**0.55**	**0.5**	**1.25**
	siteIII	**2.5**	**2.5**	**2.5**	**2**	**0.5**	**0.5**	**1**	**0.5**	**0.5**	**0.45**	**0.45**	**1.05**
2005-06	**siteI**	**2.8**	**2.8**	**2.4**	**2.1**	**1.3**	**0.6**	**0.3**	**0.5**	**0.5**	**1**	**1**	**0.8**
	siteII	**2.5**	**2.5**	**2.4**	**2**	**1.25**	**0.6**	**0.25**	**0.45**	**0.5**	**0.55**	**0.85**	**0.5**
	siteIII	**2.45**	**2.45**	**2**	**2**	**1.35**	**0.55**	**0.32**	**0.5**	**0.5**	**0.5**	**0.75**	**0.5**

Table: 7. Hydrogen ion concentration of three sites from 2002-06

Months	Sites	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
2002-03	siteI	8.5	7.9	7.8	7.8	8	8.5	8.9	9	9	8.5	8.5	8.4
	siteII	7.31	7.37	7.45	7.4	7.55	7.5	7.72	8.5	8.51	7.85	7.5	7.42
	siteIII	7.48	7.36	7.35	7	7.55	7.7	8	7.55	7.5	7.43	7.22	7.43
2003-04	siteI	8.5	8.5	7.5	7.5	7	8	8.5	9	9	8.5	8.5	8.5
	siteII	7.55	7.68	7.5	7.5	7	7.5	8	8.5	8.5	8	8	7.55
	siteIII	7.43	7.35	7.48	7.32	7.3	7.8	8	7.88	7.72	7.55	7.42	7.36
2004-05	siteI	8.5	8.5	8.5	8.5	7.5	7	7	7	9	8	8.5	8.5
	siteII	8.5	8	7.5	8	7.5	7	7	7	8.5	8	8	8.5
	siteIII	7.43	7.4	7.35	7.4	7.4	7.5	7.3	7	8.62	7.65	7.5	7.42
2005-06	siteI	8.5	8.5	8.5	8	7.5	7.5	7	7.5	7.5	8	8.5	8.5
	siteII	8	7.48	7.7	8	7.5	7.2	7	7.5	7	7.5	8	8.5
	siteIII	7.43	7.55	7.32	7	7.72	7	7.5	7.5	7.35	7.55	7.42	7.36

Table: 8 Salinity (‰) of three sites from 2003 -06													
Months	**Sites**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**
2002-04	**siteI**	12	15.5	18	18	8.25	8.5	8.25	10.5	10.7	11	15.5	12.5
	siteII	11.6	15.5	15.5	10.5	8.1	7.5	8.2	10	9.5	10.5	14.6	12.5
	siteIII	12.2	15	18	18	8.1	7.7	7.75	10	10.5	11	14	11.8
2004-05	**siteI**	14	14	14	16.4	12	8	14	15	14.3	14	15	14
	siteII	13.5	13.5	13.5	16.1	12	7.5	13.4	15	14	13.6	15	13.5
	siteIII	12	12	12	15.3	12	7.8	12	14	12.5	13.5	15	12
2005-06	**siteI**	12.9	15.8	15.8	18.8	8	7	8.2	10.7	10.7	10.9	15	12.7
	siteII	14.6	15.5	18	10	8.2	7	10	10.7	7.5	14.5	10.6	12.6
	siteIII	14.2	15	18	10	7	7.5	10	10	7.5	14	12	11.8

Table: 16 ANOVA of atmospheric temperature of site I (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	39.08333	2.611111	14.96809	0.001372
2003-04	49.08333	4.722222	10.39412	0.00458
2004-05	22.75	0.527778	43.10526	2.45E-05
2005-06	63	3.805556	16.55474	0.000965

Table: 17 ANOVA of atmospheric temperature of site II (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	47.58333	3.166667	15.02632	0.001354
2003-04	52	4.444445	11.7	0.003138
2004-05	11.08333	1.277778	8.673913	0.007957
2005-06	67.58334	3.527778	19.15748	0.000571

Table: 18 ANOVA of atmospheric temperature of site III (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	40.08333	2.5	16.03333	0.00108
2003-04	57.33333	4.888889	11.72727	0.003114
2004-05	11.58333	1.527778	7.581818	0.011745
2005-06	64.58334	4.166667	15.5	0.001216

Table: 19 ANOVA of surface water temperature of site I (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	25.33333	3.361111	7.53719	0.011942
2003-04	18.08333	2.083333	8.68	0.00794
2004-05	9.25	0.944444	9.794118	0.005511
2005-06	23.08333	1.833333	12.59091	0.002466

Table: 20 ANOVA of surface water temperature of site II (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	45.08333	12.97222	3.475375	0.076134
2003-04	31	2.111111	14.68421	0.001466
2004-05	12.25	1.388889	8.82	0.007572
2005-06	39.08333	1.833333	21.31818	0.000385

Table: 21 ANOVA of surface water temperature of site III (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	39.25	1.055556	37.18421	4.46E-05
2003-04	33.25	1.055556	31.5	8.63E-05
2004-05	16.08333	2.305556	6.975904	0.014805
2005-06	42.33333	1.583333	26.73684	0.000163

Table: 22 ANOVA of dipped water temperature of site I (2002-06)

Years	MS effect	Ms error	F(dfl,2)2,9	p-level
2002-03	22.75	2.083333	10.92	0.003918
2003-04	14.08333	1.833333	7.681818	0.011318
2004-05	11.58333	1.527778	7.581818	0.011745
2005-06	7.583333	2.277778	3.329268	0.082739

Table: 23 ANOVA of dipped water temperature of site II (2002-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2002-03	18.25	2.166667	8.423077	0.008676
2003-04	22.58333	1.388889	16.26	0.001028
2004-05	4.083333	4.388889	0.93038	0.42926
2005-06	18.08333	1.194444	15.13953	0.001319

Table: 24 ANOVA of dipped water temperature of site III (2002-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2002-03	20.58333	1.75	11.7619	0.003085
2003-04	20.58333	0.944444	21.79412	0.000355
2004-05	3.583333	3.972222	0.902098	0.439466
2005-06	16.08333	1.055556	15.23684	0.00129

Table: 25 ANOVA of dissolved oxygen content of site I (2002-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2002-03	4.954924	0.591032	8.383512	0.008796
2003-04	3.791754	0.215931	17.56006	0.000782
2004-05	4.457795	0.534733	8.336492	0.008942
2005-06	3.211365	0.162352	19.78026	0.000508

Table: 26 ANOVA of dissolved oxygen content of site II (2002-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2002-03	1.965961	0.288506	6.814288	0.015781
2003-04	3.936517	0.115339	34.13007	6.28E-05
2004-05	4.057024	0.318628	12.73279	0.002376
2005-06	1.84824	0.163407	11.31069	0.003501

Table: 27 ANOVA of dissolved oxygen content of site III (2002-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2002-03	1.84824	0.163407	11.31069	0.003501
2003-04	3.867124	0.116334	33.24169	6.98E-05
2004-05	2.302192	0.356041	6.466089	0.018164
2005-06	3.887272	0.095379	40.75606	3.08E-05

Table: 28 ANOVA of phosphate content of site I (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	0.536108	0.086564	6.19321	0.020346
2003-04	0.262975	0.02515	10.45626	0.004495
2004-05	0.619375	0.052431	11.81324	0.003041
2005-06	0.648308	0.094386	6.868684	0.015444

Table: 29 ANOVA of phosphate content of site II (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	0.202533	0.0454	4.461087	0.045064
2003-04	0.225808	0.032417	6.96581	0.014864
2004-05	0.399225	0.028083	14.21573	0.001639
2005-06	0.254775	0.033986	7.496445	0.012126

Table: 30 ANOVA of phosphate content of site III (2002-06)

Years	MS effect	MS error	F(df1,2) 2,9	p-level
2002-03	1.84824	0.163407	11.31069	0.003501
2003-04	0.104633	0.114922	0.910471	0.436414
2004-05	0.290325	0.040061	7.247053	0.013328
2005-06	0.565733	0.084247	6.715157	0.016418

Table: 31 ANOVA of carbondioxide content of site I (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	2.350833	0.256111	9.178959	0.006718
2003-04	1.490833	0.463889	3.213773	0.088462
2004-05	2.433958	0.306597	7.938618	0.010303
2005-06	2.73	0.198056	13.78401	0.00182

Table: 32 ANOVA of free carbondioxide content of site II (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	1.995208	0.194653	10.25009	0.004785
2003-04	1.1425	0.533056	2.143304	0.173272
2004-05	1.918958	0.239931	7.997974	0.010085
2005-06	1.286458	0.276042	4.660378	0.040817

Table: 33 ANOVA of free carbondioxide content of site III (2002-06)

Years	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	0.254775	0.033986	7.496445	0.012126
2003-04	0.692708	0.310764	2.22905	0.163555
2004-05	2.543958	0.216042	11.77531	0.003073
2005-06	2.502658	0.125172	19.99372	0.000488

Table: 34 ANOVA of hydrogen ion content of site I (2002-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2002-03	0.48	0.131111	3.661017	0.068645
2003-04	0.4375	0.375	1.166667	0.35439
2004-05	2.520833	0.076389	33	7.18E-05
2005-06	1.083333	0.118056	9.176471	0.006723

Table: 35 ANOVA of hydrogen ion content of site II (2002-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2002-03	0.259658	0.152572	1.701872	0.236104
2003-04	0.208658	0.191506	1.089568	0.376924
2004-05	1.395833	0.104167	13.4	0.002003
2005-06	0.181108	0.034208	5.294275	0.030205

Table: 36 ANOVA of hydrogen ion content of site III (2002-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2002-03	0.181108	0.034208	5.294275	0.030205
2003-04	0.130825	0.042131	3.105228	0.094287
2004-05	0.279025	0.119175	2.341305	0.151821
2005-06	0.013433	0.052389	0.256416	0.779287

Table: 37 ANOVA of salinity content of site I (2003-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2003-04	47.78271	4.647917	10.28046	0.004741
2004-05	1.6525	1.186111	1.393208	0.029708
2005-06	47.27083	3.767222	12.54793	0.002494

Table: 38 ANOVA of salinity content of site II (2003-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2003-04	21.7575	4.228333	5.145645	0.032357
2004-05	1.315833	1.399722	0.940067	0.425831
2005-06	28.53083	7.299445	3.908631	0.060006

Table: 39 ANOVA of salinity content of site III (2002-06)

Years	MS effect	MS error	F(dfl,2)2,9	p-level
2003-04	51.52146	3.670486	14.03668	0.001711
2004-05	0.640833	1.849722	0.346448	0.716226
2005-06	32.7925	7.035	4.661336	0.040798

Table: 40 ANOVA of atmospheric temperature between sites

	Seasons	MS effect	MS error	F(df1,2)2,9	p-level
	Premonsoon	0.333333	6.25	0.053333	0.948361
	Monsoon	0.75	0.611111	1.227273	0.337824
	Postmonsoon	0.083333	1.416667	0.058824	0.943233
	Premonsoon	0.083333	2.083333	0.04	0.960959
	Monsoon	0.333333	3.666667	0.090909	0.913928
	Postmonsoon	1.75	8.305555	0.210702	0.8139
	Premonsoon	6.75	2.055556	3.283784	0.084937
	Monsoon	0.583333	0.611111	0.954545	0.420768
	Postmonsoon	1	0.666667	1.5	0.274016
	Premonsoon	0.25	6.5	0.038462	0.962426
	Monsoon	0.472222	0.705882	0.519077	0.083333
	Postmonsoon	4.527778	0.018405	0.9818	4.527778

Table: 41 ANOVA of surface water temperature between sites

	Seasons	MS effect	MS error	F(df1,2)2,9	p-level
	Premonsoon	0.75	2.388889	0.313953	0.73824
	Monsoon	4.083333	2.944444	1.386792	0.29854
	Postmonsoon	10.58333	12.05556	0.87788	0.448442
	Premonsoon	0.75	0.972222	0.771429	0.490658
4	Monsoon	6.083333	1.638889	3.711864	0.066753
	Postmonsoon	3.25	2.638889	1.231579	0.336684
	Premonsoon	3.583333	2.277778	1.573171	0.25947
5	Monsoon	1.75	0.722222	2.423077	0.143916
	Postmonsoon	0.083333	1.638889	0.050847	0.950695
	Premonsoon	0.333333	1.138889	0.292683	0.753099
6	Monsoon	6.083333	1.638889	3.711864	0.066753
	Postmonsoon	1	2.472222	0.404494	0.678863

Table: 42 ANOVA of dipped water temperature between sites

Years	Seasons	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	Premonsoon	1.333333	0.222222	6	0.022085
	Monsoon	0.583333	2.277778	0.256098	0.779521
	Postmonsoon	0.75	3.5	0.214286	0.811119
2003-04	Premonsoon	1.75	1.194444	1.465116	0.281301
	Monsoon	5.333333	1.138889	4.682927	0.040368
	Postmonsoon	5.25	1.833333	2.863636	0.109029
2004-05	Premonsoon	8.333333	2.694444	3.092783	0.094984
	Monsoon	1.333333	0.666667	2	0.191138
	Postmonsoon	4.75	6.527778	0.72766	0.509417
2005-06	Premonsoon	0.583333	1.972222	0.295775	0.750917
	Monsoon	5.333333	1.138889	4.682927	0.040368
	Postmonsoon	2.083333	1.416667	1.470588	0.280143

Table: 43 ANOVA of dissolved oxygen content between sites

Years	Seasons	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	Premonsoon	0.152065	0.164915	0.922082	0.432224
	Monsoon	1.201804	0.571896	2.101438	0.178272
	Postmonsoon	0.022546	0.306133	0.073649	0.929552
2003-04	Premonsoon	0.156009	0.248853	0.626914	0.556038
	Monsoon	0.104924	0.041054	2.555764	0.132132
	Postmonsoon	0.511682	0.157696	3.244741	0.086881
2004-05	Premonsoon	0.075508	0.322374	0.234225	0.79586
	Monsoon	0.608401	0.476801	1.276006	0.325186
	Postmonsoon	0.004139	0.410226	0.01009	0.989972
2005-06	Premonsoon	0.004129	0.200887	0.020556	0.9797
	Monsoon	0.015987	0.169192	0.09449	0.910727
	Postmonsoon	0.002416	0.040037	0.060344	0.941819

Table: 44 ANOVA of free carbondioxide content between sites

Seasons	MS effect	MS error	F(df1,2)2,9	p-level
Premonsoon	0.125833	0.398333	0.3159	0.736899
Monsoon	0.003333	0.008889	0.375	0.697542
Postmonsoon	0.019375	0.319583	0.060626	0.941556
Premonsoon	0.1825	0.546389	0.334011	0.724556
Monsoon	0.145833	0.744167	0.195969	0.825454
Postmonsoon	0.003958	0.017153	0.230769	0.798479
Premonsoon	0.055833	0.559167	0.099851	0.905961
Monsoon	0.005208	0.054097	0.096277	0.909135
Postmonsoon	0.030625	0.149306	0.205116	0.818257
Premonsoon	0.050208	0.322986	0.15545	0.858279
Monsoon	0.002158	0.195242	0.011055	0.98902
Postmonsoon	0.080625	0.033264	2.4238	0.143849

Table: 45 ANOVA of phosphate content between sites

Seasons	MS effect	MS error	F(df1,2)2,9	p-level
Premonsoon	0.002708	0.013883	0.195078	0.826159
Monsoon	0.1216	0.129111	0.941824	0.425212
Postmonsoon	0.026133	0.022956	1.138432	0.362446
Premonsoon	0.061425	0.113819	0.539671	0.600685
Monsoon	0.006775	0.053919	0.12565	0.883443
Postmonsoon	0.009325	0.00475	1.963158	0.19609
Premonsoon	0.018925	0.023528	0.804368	0.477095
Monsoon	0.049758	0.086997	0.571953	0.583671
Postmonsoon	0.013358	0.01005	1.329187	0.312047
Premonsoon	0.004058	0.01665	0.243744	0.788698
Monsoon	0.079908	0.177431	0.450364	0.651012
Postmonsoon	0.005008	0.007075	0.707892	0.518176

Table: 46 ANOVA of hydrogen ion content between sites

Years	Seasons	MS effect	MS error	F(df1,2)2,9	p-level
2002-03	Premonsoon	0.588025	0.053194	11.05426	0.003768
	Monsoon	0.941858	0.153197	6.148012	0.020737
	Postmonsoon	1.494033	0.1115	13.3994	0.002003
2003-04	Premonsoon	0.392158	0.115308	3.400954	0.079414
	Monsoon	0.1875	0.413811	0.453105	0.649393
	Postmonsoon	1.241875	0.079517	15.61779	0.001184
2004-05	Premonsoon	1.2247	0.055922	21.90006	0.000349
	Monsoon	0.040833	0.057222	0.713592	0.515632
	Postmonsoon	0.507175	0.186586	2.718182	0.11927
2005-06	Premonsoon	1.106533	0.060789	18.20289	0.000687
	Monsoon	0.017033	0.071811	0.237196	0.793615
	Postmonsoon	0.4977	0.2181	2.281981	0.157889

Table: 47 ANOVA of salinity content between sites

Years	Seasons	MS effect	MS error	F(df1,2)2,9	p-level
2003-04	Premonsoon	8.846458	7.497917	1.179855	0.350702
	Monsoon	0.1225	0.963056	0.127199	0.882113
	Postmonsoon	0.544375	4.085764	0.133237	0.876952
2004-05	Premonsoon	3.405833	1.950833	1.745835	0.228717
	Monsoon	0.9025	1.670833	0.54015	0.600428
	Postmonsoon	1.230833	0.813889	1.512287	0.271505
2005-06	Premonsoon	2.710833	9.288333	0.291854	0.753686
	Monsoon	0.425833	2.002778	0.212621	0.812409
	Postmonsoon	1.3675	6.810555	0.200791	0.82165

Table: 48 Simple correlations of physico-chemical parameters of site I during 2002-03

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH
Atmospheric temperature	1 p= ---						
Surface temperature	0.6964 p=.012	1 p= ---					
Dipped water temperature	0.7114 p=.009	0.9604 p=.000	1 p= ---				
Dissolved oxygen	-0.5735 p=.051	-0.7363 p=.006	-0.8087 p=.001	1 p= ---			
Free carbondioxide	0.808 p=.001	0.6412 p=.025	0.6881 p=.013	-0.679 p=.015	1 p= ---		
Phosphate	-0.5028 p=.096	-0.7113 p=.009	-0.7778 p=.003	0.7238 p=.008	-0.5748 p=.051	1 p= ---	
pH	-0.7797 p=.003	-0.6611 p=.019	-0.7078 p=.010	0.6246 p=.030	-0.6947 p=.012	0.4758 p=.118	1 p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 49 Simple correlations of physico-chemical parameters of site I during 2003-04

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH	Salinity
Atmospheric temperature	1 p= ---							
Surface temperature	0.8268 p=.001	1 p= ---						
Dipped water temperature	0.6728 p=.016	0.8749 p=.000	1 p= ---					
Dissolved oxygen	-0.9242 p=.000	-0.7913 p=.002	-0.7155 p=.009	1 p= ---				
Free carbondioxide	0.5221 p=.082	0.3539 p=.259	0.399 p=.199	-0.3732 p=.232	1 p= ---			
Phosphate	-0.559 p=.059	-0.6527 p=.021	-0.6314 p=.028	0.7315 p=.007	0.2284 p=.475	1 p= ---		
pH	-0.4703 p=.123	-0.3109 p=.325	-0.2903 p=.360	0.2877 p=.365	-0.8613 p=.000	-0.2992 p=.345	1 p= ---	
Salinity	0.8493 p=.000	0.783 p=.003	0.7095 p=.010	-0.8989 p=.000	0.2571 p=.420	-0.7287 p=.007	-0.2028 p=.527	1 p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 50 Simple correlations of physico-chemical parameters of site I during 2004-05

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH	Salinity
Atmospheric temperature	1							
	p= ---							
Surface temperature	0.8009	1						
	p=.002	p= ---						
Dipped watertemperature	0.8184	0.8077	1					
	p=.001	p=.001	p= ---					
Dissolved oxygen	-0.8427	-0.6515	-0.6913	1				
	p=.001	p=.022	p=.013	p= ---				
Free carbondioxide	0.6506	0.4233	0.6737	-0.7058	1			
	p=.022	p=.170	p=.016	p=.010	p= ---			
Phosphate	-0.7618	-0.6143	-0.6245	0.5399	-0.5729	1		
	p=.004	p=.034	p=.030	p=.070	p=.052	p= ---		
pH	0.8177	0.7839	0.6905	-0.681	0.4233	-0.6928	1	
	p=.001	p=.003	p=.013	p=.015	p=.170	p=.013	p= ---	
Salinity	0.5244	0.5868	0.3962	-0.193	0.2542	-0.7402	0.3855	1
	p=.080	p=.045	p=.202	p=.548	p=.425	p=.006	p=.216	p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 51 Simple correlations of physico-chemical parameters of site I during 2005-06

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH	Salinity
Atmospheric temperature	1							
	p= ---							
Surface temperature	0.7185	1						
	p=.008	p= ---						
Dipped water temperature	0.377	0.6698	1					
	p=.227	p=.017	p= ---					
Dissolved oxygen	-0.7249	-0.7574	-0.6187	1				
	p=.008	p=.004	p=.032	p= ---				
Free carbondioxide	0.6127	0.7557	0.5258	-0.7838	1			
	p=.034	p=.004	p=.079	p=.003	p= ---			
Phosphate	-0.6877	-0.6102	-0.4985	0.6834	-0.3987	1		
	p=.013	p=.035	p=.099	p=.014	p=.199	p= ---		
pH	0.8957	0.8318	0.3805	-0.7857	0.6333	-0.6542	1	
	p=.000	p=.001	p=.222	p=.002	p=.027	p=.021	p= ---	
Salinity	0.667	0.7531	0.6673	-0.9097	0.7498	-0.7104	0.7332	1
	p=.018	p=.005	p=.018	p=.000	p=.005	p=.010	p=.007	p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 52 Simple correlations of physico-chemical parameters of site II during 2002-03

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH
Atmospheric temperature	1 p= ---						
Surface temperature	0.7241 p=.008	1 p= ---					
Dipped water temperature	0.6249 p=.030	0.7246 p=.008	1 p= ---				
Dissolved oxygen	-0.688 p=.013	-0.7046 p=.011	-0.8655 p=.000	1 p= ---			
Free carbondioxide	0.8365 p=.001	0.699 p=.011	0.6301 p=.028	-0.8315 p=.001	1 p= ---		
Phosphate	-0.4081 p=.188	-0.5153 p=.086	-0.7422 p=.006	0.6686 p=.017	-0.5252 p=.080	1 p= ---	
pH	-0.4972 p=.100	-0.79 p=.002	-0.5041 p=.095	0.5221 p=.082	-0.5268 p=.078	0.4338 p=.159	1 p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 53 Simple correlations of physico-chemical parameters of site II during 2003-04

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH	Salinity
Atmospheric temperature	1 p= ---							
Surface temperature	0.8889 p=.000	1 p= ---						
Dipped water temperature	0.8999 p=.000	0.9511 p=.000	1 p= ---					
Dissolved oxygen	-0.9182 p=.000	-0.9349 p=.000	-0.9445 p=.000	1 p= ---				
Free carbondioxide	0.501 p=.097	0.1774 p=.581	0.2202 p=.492	-0.3228 p=.306	1 p= ---			
Phosphate	-0.4243 p=.169	-0.6379 p=.026	-0.7 p=.011	0.6406 p=.025	0.3746 p=.230	1 p= ---		
pH	-0.5513 p=.063	-0.306 p=.333	-0.3021 p=.340	0.3743 p=.231	-0.745 p=.005	-0.3088 p=.329	1 p= ---	
Salinity	0.6966 p=.012	0.7701 p=.003	0.7582 p=.004	-0.7681 p=.004	-0.0655 p=.840	-0.7266 p=.007	-0.0609 p=.851	1 p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 54 Simple correlations of physico-chemical parameters of site II during 2004-05

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH	Salinity
Atmospheric temperature	1 p= ---							
Surface temperature	0.595 p=.041	1 p= ---						
Dipped water temperature	0.466 p=.127	0.4524 p=.140	1 p= ---					
Dissolved oxygen	-0.7667 p=.004	-0.2085 p=.516	-0.4868 p=.108	1 p= ---				
Free carbondioxide	0.5132 p=.088	0.0386 p=.905	0.3011 p=.342	-0.771 p=.003	1 p= ---			
Phosphate	-0.6236 p=.030	-0.3207 p=.309	-0.3885 p=.212	0.7375 p=.006	-0.5779 p=.049	1 p= ---		
pH	0.6173 p=.032	0.5321 p=.075	0.2563 p=.421	-0.4959 p=.101	0.1159 p=.720	-0.6869 p=.014	1 p= ---	
Salinity	0.1008 p=.755	0.436 p=.156	0.0476 p=.883	-0.1038 p=.748	0.1109 p=.732	-0.5304 p=.076	0.2317 p=.469	1 p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 55 Simple correlations of physico-chemical parameters of site II during 2005-06

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH	Salinity
Atmospheric temperature	1 p= ---							
Surface temperature	0.8247 p=.001	1 p= ---						
Dipped water temperature	0.7392 p=.006	0.9253 p=.000	1 p= ---					
Dissolved oxygen	-0.7717 p=.003	-0.8927 p=.000	-0.9309 p=.000	1 p= ---				
Free carbondioxide	0.5367 p=.072	0.5973 p=.040	0.6706 p=.017	-0.7181 p=.009	1 p= ---			
Phosphate	-0.8218 p=.001	-0.7523 p=.005	-0.7617 p=.004	0.7845 p=.003	-0.5101 p=.090	1 p= ---		
pH	0.5206 p=.083	0.7406 p=.006	0.646 p=.023	-0.6134 p=.034	0.2091 p=.514	-0.3738 p=.231	1 p= ---	
Salinity	0.7118 p=.009	0.7109 p=.010	0.739 p=.006	-0.6861 p=.014	0.5411 p=.069	-0.7201 p=.008	0.3765 p=.228	1 p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 56 Simple correlations of physico-chemical parameters of site III during 2002-03

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH
Atmospheric temperature	1						
	p= ---						
Surface temperature	0.8732	1					
	p=.000	p= ---					
Dipped water temperature	0.6759	0.8761	1				
	p=.016	p=.000	p= ---				
Dissolved oxygen	-0.5946	-0.849	-0.8373	1			
	p=.041	p=.000	p=.001	p= ---			
Free carbondioxide	0.7717	0.6873	0.5317	-0.5873	1		
	p=.003	p=.014	p=.075	p=.045	p= ---		
Phosphate	-0.459	-0.6446	-0.7394	0.6707	-0.5506	1	
	p=.133	p=.024	p=.006	p=.017	p=.064	p= ---	
pH	-0.6229	-0.7253	-0.6047	0.6467	-0.4802	0.7956	1
	p=.030	p=.008	p=.037	p=.023	p=.114	p=.002	p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 57 Simple correlations of physico-chemical parameters of site III during 2003-04

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH	Salinity
Atmospheric temperature	1 p= ---							
Surface temperature	0.8924 p=.000	1 p= ---						
Dipped water temperature	0.9049 p=.000	0.944 p=.000	1 p= ---					
Dissolved oxygen	-0.8509 p=.000	-0.9653 p=.000	-0.9121 p=.000	1 p= ---				
Free carbondioxide	0.5273 p=.078	0.2945 p=.353	0.2457 p=.441	-0.3142 p=.320	1 p= ---			
Phosphate	-0.0176 p=.957	-0.1512 p=.639	-0.2931 p=.355	0.2056 p=.522	0.5998 p=.039	1 p= ---		
pH	-0.6892 p=.013	-0.6921 p=.013	-0.6036 p=.038	0.6989 p=.011	-0.5081 p=.092	-0.0011 p=.997	1 p= ---	
Salinity	0.8247 p=.001	0.9125 p=.000	0.8721 p=.000	-0.9548 p=.000	0.3068 p=.332	-0.1293 p=.689	-0.5767 p=.050	1 p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 58 Simple correlations of physico-chemical parameters of site III during 2004-05

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH	Salinity
Atmospheric temperature	1 p= ---							
Surface temperature	0.5562 p=.060	1 p= ---						
Dipped water temperature	0.6804 p=.015	0.4914 p=.105	1 p= ---					
Dissolved oxygen	-0.7293 p=.007	-0.309 p=.328	-0.7122 p=.009	1 p= ---				
Free carbondioxide	0.5294 p=.077	-0.0184 p=.955	0.1624 p=.614	-0.6795 p=.015	1 p= ---			
Phosphate	-0.7108 p=.010	-0.4095 p=.186	-0.4547 p=.137	0.4651 p=.128	-0.5001 p=.098	1 p= ---		
pH	-0.0416 p=.898	0.2861 p=.367	-0.4994 p=.098	0.4291 p=.164	-0.2419 p=.449	-0.0108 p=.973	1 p= ---	
Salinity	-0.0023 p=.994	0.4386 p=.154	0.1103 p=.733	-0.1535 p=.634	-0.1002 p=.757	0.0168 p=.959	-0.0961 p=.766	1 p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 59 Simple correlations of physico-chemical parameters of site III during 2005-06

	Atmospheric temperature	Surface temperature	Dipped water temperature	Dissolved oxygen	Free carbondioxide	Phosphate	pH	Salinity
Atmospheric temperature	1							
	p= ---							
Surface temperature	0.7191	1						
	p=.008	p= ---						
Dipped water temperature	0.776	0.932	1					
	p=.003	p=.000	p= ---					
Dissolved oxygen	-0.8268	-0.9043	-0.9301	1				
	p=.001	p=.000	p=.000	p= ---				
Free carbondioxide	0.54	0.6784	0.6327	-0.7237	1			
	p=.070	p=.015	p=.027	p=.008	p= ---			
Phosphate	-0.6544	-0.6568	-0.6163	0.6002	-0.2179	1		
	p=.021	p=.020	p=.033	p=.039	p=.496	p= ---		
pH	0.0201	-0.1849	-0.1112	0.2294	-0.0577	0.4215	1	
	p=.951	p=.565	p=.731	p=.473	p=.859	p=.172	p= ---	
Salinity	0.7723	0.7324	0.831	-0.683	0.5007	-0.6052	0.1483	1
	p=.003	p=.007	p=.001	p=.014	p=.097	p=.037	p=.645	p= ---

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 60. Monthly variation of zooplankton at site I during 2004-05

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
A. major	794	800	780	820	612	388	406	610	700	780	832	812
A.gracilis	652	600	560	640	446	206	308	346	450	458	620	600
C.pauper	300	300	300	360	170	70	85	180	320	326	230	212
C.scutifer	892	900	798	916	532	298	342	482	502	510	826	800
D.parvus	240	250	260	280	100	58	60	88	100	106	160	210
E.alcifrons	148	150	152	150	56	42	34	50	54	60	162	160
L.hanseni	132	150	160	162	80	80	106	94	80	84	168	140
M.dobsoni	200	285	272	276	134	82	90	100	120	124	108	100
M.leuckarti	290	350	352	360	166	83	80	110	158	164	200	260
M.meretrix	140	113	218	204	52	66	88	106	248	240	112	60
O.bravicornis	120	100	110	146	64	46	42	66	60	64	102	98
O.similis	98	120	126	120	38	32	40	30	34	36	96	128
P.aurivelli	200	200	240	260	76	36	30	56	50	56	200	216
P.indicus	276	300	320	300	126	72	84	118	132	136	262	252
P.parvus	196	200	200	220	106	76	66	76	98	104	230	180
S.inflatta	300	318	320	326	226	210	212	200	240	248	146	120
S.lanatum	448	420	446	480	280	222	230	266	320	324	324	180
S.minor	70	55	60	102	28	14	16	36	26	30	76	78
T.philetaerus	0	0	0	0	12	8	8	4	0	0	0	0
T.telescopium	220	103	184	112	108	78	96	112	128	120	150	28

Table: 61. Monthly variations of zooplanktons at site I during 2005-06

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
A. major	810	308	378	496	722	778	766	844	828	846	850	997
A.gracillis	620	250	206	334	560	568	556	620	610	634	630	740
C.pauper	300	124	60	222	180	204	192	230	232	244	250	460
C.scutifer	900	206	288	776	700	758	746	826	806	840	808	916
D.parvus	260	100	53	216	182	198	186	160	215	174	176	280
E.alcifrons	150	40	32	164	146	146	124	162	152	156	162	150
L.hanseni	150	42	70	144	102	126	138	168	116	182	186	162
M.dobsoni	285	54	82	118	76	100	274	108	98	122	126	276
M.leuckarti	350	184	82	264	210	246	224	200	250	218	222	460
M.meretrix	113	18	66	74	46	56	100	116	56	126	128	204
O.bravicornis	100	50	36	104	72	86	74	102	88	116	118	246
O.similis	120	44	32	132	74	114	102	96	116	110	114	120
P.aurivelli	200	80	36	218	196	200	288	200	220	218	216	260
P.indicus	300	38	62	264	194	246	290	262	240	276	280	300
P.parvus	210	66	76	184	164	166	154	230	185	246	250	220
S.enflatta	318	30	205	130	88	112	306	146	110	160	162	325
S.lenatum	420	42	212	186	104	168	410	324	176	338	340	480
S.minor	55	26	14	86	52	68	44	76	68	90	94	102
T.philetaerus	0	6	8	0	10	8	8	4	0	0	0	0
T.telescopium	103	12	78	70	90	40	90	150	28	164	166	112

Table: 62. Monthly variations of zooplanktons at site II 2004-05

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
A. major	70	78	94	190	56	44	44	42	56	62	70	66
A.gracillis	54	60	68	88	45	38	36	44	36	50	56	52
C.pauper	52	56	58	86	40	28	26	36	38	46	52	50
C.scutifer	56	64	86	128	28	24	24	42	24	44	58	56
D,parvus	44	50	56	70	32	24	24	30	26	34	48	46
E.alcifrons	28	32	36	44	28	22	24	22	26	24	32	26
L.hanseni	50	48	50	54	30	18	16	26	32	30	44	42
M.dobsoni	52	56	56	64	38	16	12	30	36	46	52	50
M.leuckarti	50	50	54	64	54	40	38	30	38	42	46	48
M.meretrix	12	18	22	32	6	4	8	14	18	18	22	10
O.bravicornis	24	36	38	52	36	30	28	24	38	26	28	28
O.similis	32	38	42	50	16	12	12	18	24	28	34	30
P.aurivelli	40	44	46	68	26	24	29	22	30	36	42	42
P.indicus	34	42	46	52	22	20	22	26	28	40	40	36
P.parvus	46	48	50	78	40	35	30	32	28	38	44	42
S.enflatta	26	30	34	46	14	8	8	20	22	20	32	26
S.lenatum	44	54	56	66	30	12	12	32	36	42	54	46
S.serrata	12	16	18	26	8	4	2	12	16	14	16	12
T.philetaerus	0	0	0	0	2	8	2	4	0	0	0	0
T.telescopium	8	10	14	18	4	4	4	6	8	6	18	8

Table: 63. Monthly variations of zooplanktons at site II 2005-06

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
A. major	58	42	40	72	60	70	180	92	78	88	94	70
A.gracillis	36	34	34	60	54	56	78	68	58	60	66	50
C.pauper	40	26	26	56	50	52	76	58	56	60	58	52
C.scutifer	26	22	22	48	38	58	118	62	62	64	76	50
D,parvus	28	22	20	34	42	48	60	54	50	50	54	46
E.alcifrons	28	22	22	24	28	34	44	30	30	42	36	0
L.hanseni	32	14	14	30	30	44	54	46	46	54	50	34
M.dobsoni	36	12	12	46	38	52	54	54	54	60	56	26
M.leuckarti	40	38	36	42	64	46	54	48	48	30	54	24
M.meretrix	20	8	6	18	6	24	32	18	18	22	22	18
O.bravicornis	38	28	28	26	36	28	52	34	34	38	38	32
O.similis	26	10	8	28	16	34	50	36	36	44	42	28
P.aurivelli	32	26	24	36	36	42	68	44	44	48	44	56
P.indicus	28	20	20	40	22	42	52	42	42	50	50	52
P.parvus	30	28	28	38	50	44	68	50	46	50	50	42
S.enflatta	24	8	8	20	14	34	46	30	30	38	34	44
S.lenatum	36	12	10	42	30	54	66	54	54	54	56	12
S. serrata	18	4	4	14	8	16	26	16	16	20	18	50
T.philetaerus	0	0	0	0	6	2	4	4	4	0	0	12
T.telescopium	10	4	4	6	4	18	10	10	10	18	14	8

Table: 64. Monthly variations of zooplanktons at site III 2004-05

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
A. major	620	780	478	590	380	306	296	416	802	622	770	722
A.gracillis	358	568	316	446	266	252	240	358	600	456	558	560
C.pauper	190	204	90	190	86	104	88	86	212	180	194	180
D,parvus	92	198	68	80	70	90	84	62	210	110	188	182
P.parvus	78	166	74	86	78	64	50	66	180	106	176	164
P.aurivelli	60	200	36	56	68	72	50	30	216	86	190	196
C.scutifer	492	758	412	62	228	206	188	342	800	542	748	708
M.leuckarti	112	246	80	146	182	174	154	80	260	166	246	210
O.bravicornis	76	86	42	44	52	50	30	42	98	64	86	72
O.similis	30	114	40	38	50	44	24	40	128	38	116	74
E.alcifrons	46	146	34	0	44	40	26	34	160	56	148	146
T.philetaerus	0	0	0	36	2	6	0	8	0	12	0	0
S.minor	32	68	76	36	26	26	20	16	78	28	68	52
L.hanseni	84	126	106	60	54	42	28	106	140	80	126	102
P.indicus	98	246	84	106	52	38	26	84	252	126	246	194
M.dobsoni	94	100	90	114	64	654	46	90	100	134	100	76
S.enflatta	180	112	212	206	46	30	28	212	120	226	112	88
S.lenatum	252	168	230	240	66	42	34	230	180	280	168	104
M.meretrix	100	56	88	32	32	18	18	88	60	52	56	46
T.telescopium	104	40	96	88	18	12	10	96	28	108	40	90

Table: 65. Monthly variations of zooplanktons at site III 2005-06

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
A. major	622	398	392	300	388	380	480	484	274	496	714	780
A.gracillis	358	284	236	250	266	274	318	320	260	334	552	568
C.pauper	192	104	84	100	90	70	90	92	80	108	172	204
D,parvus	92	90	80	90	74	58	68	70	74	86	174	198
P.parvus	78	96	46	62	80	76	76	78	70	94	156	186
P.aurivelli	60	80	44	70	70	36	36	36	62	56	188	200
C.scutifer	492	248	184	200	228	298	412	414	222	430	700	758
M.leuckarti	114	200	150	172	186	82	82	84	176	98	202	256
O.bravicornis	76	70	26	48	54	46	44	46	46	60	66	96
O.similis	30	68	20	40	50	32	40	42	44	66	64	126
E.alcifrons	46	62	22	40	46	42	36	38	38	64	138	158
T.philetaerus	0	0	0	0	2	8	8	10	2	98	0	0
S.minor	32	44	16	24	28	14	76	78	20	126	50	78
L.hanseni	84	74	14	40	56	80	106	108	54	104	96	136
P.indicus	98	70	22	34	52	72	84	88	46	110	188	256
M.dobsoni	94	84	42	52	66	82	90	90	56	323	70	110
S.enflatta	180	66	24	30	48	210	212	212	40	248	80	122
S.lenatum	252	86	30	40	66	222	230	230	60	106	94	178
M.meretrix	100	52	14	16	34	66	88	90	26	114	40	56
T.telescopium	104	108	6	12	18	8	96	100	12		82	40

Table: 66. Monthly variations of crabs at site I during 2004-05

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
C.feriatus	20	16	14	0	0	0	5	5	8	10	8	12
C.lucifera	18	12	12	4	0	2	2	2	2	2	10	4
D.intermedia	0	2	2	0	0	0	0	0	0	0	0	0
D.myctiroides	4	6	0	2	0	0	0	4	0	2	2	5
G.annulipes	40	42	30	26	0	0	0	56	52	54	46	52
M.messor	0	2	0	0	0	0	0	6	0	4	2	4
S.granulata	0	0	0	0	0	0	0	0	0	6	0	0
S.lenatum	0	0	0	0	0	0	0	0	4	0	0	0
S.serrata	86	0	70	24	0	0	0	164	168	132	120	92
S.taeniolata	0	4	0	0	0	0	0	0	6	6	5	4
U.acuta	86	76	78	60	16	0	0	14	52	86	84	84
U.lactea	98	82	86	72	46	0	0	0	72	104	98	96

Table: 67. Monthly variations of crabs at site I during 2005-06

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
C.feriatus	10	12	14	8	2	2	4	4	6	14	10	10
C.lucifera	6	4	4	4	0	0	0	0	0	0	2	6
D. intermedia	0	4	4	4	0	0	0	0	0	0	0	0
D.myctiroides	2	2	8	6	0	0	4	6	0	2	2	2
G.annulipes	50	54	64	60	28	22	18	10	46	40	50	50
M.messor	2	4	6	2	0	0	0	0	0	0	2	2
S.granulata	0	2	0	0	0	0	0	0	0	0	0	0
S.lenatum	2	0	0	0	0	0	0	0	0	0	0	2
S.serrata	66	64	60	60	10	10	16	14	24	36	34	36
S.taeniolata	0	6	0	0	0	0	2	2	0	2	2	0
U.acuta	50	54	62	60	12	12	12	12	24	30	26	28
U.lactea	70	72	68	70	28	30	26	28	62	60	56	52

Table: 68. Monthly variations of crabs at site II during 2004-05

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
D.myctiroides	4	4	2	2	2	0	0	0	0	0	0	2
S.taeniolata	6	10	12	4	0	0	0	0	4	4	4	4
S.serrata	70	78	74	72	4	4	4	6	66	68	70	66
U.lactea	102	106	100	102	2	0	14	0	86	92	90	90

Table: 69. Monthly variations of crabs at site II during 2005-06

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
D.myctiroides	0	0	2	2	2	2	0	0	0	2	0	0
S.taeniolata	46	50	56	54	0	0	0	0	34	38	28	32
S.serrata	6	6	4	4	4	0	0	0	0	4	6	6
U.lactea	54	56	66	58	0	0	0	0	46	44	52	54

Table: 70. Monthly variations of crabs at site III during 2004-05

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
D.myctiroides	6	8	6	6	0	0	0	0	0	2	2	6
P.pelagicus	0	0	0	0	0	0	6	0	0	0	0	0
S.taeniolata	2	2	0	0	0	0	0	0	0	0	2	2
S.serrata	46	44	54	34	4	6	2	2	46	44	52	34
U.lactea	54	56	66	58	14	14	20	16	48	50	42	36
U.acuta	46	44	56	54	10	12	10	10	30	36	28	26

Table: 71. Monthly variations of crabs at site III during 2005-06

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
D.myctiroides	6	4	4	4	4	4	0	0	0	0	0	6
S.serrata	52	60	62	60	10	12	0	10	50	48	60	58
U.lactea	56	58	66	68	14	16	16	16	54	56	60	54

Table: 72. Monthly variations of molluscs in site I during 2004-05

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
B.granulata	2	4	6	2	0	0	0	0	2	4	2	2
B.spinosa	2	6	8	4	0	0	0	2	4	8	8	6
B.tuberculata	2	2	4	2	0	0	0	0	2	2	4	2
C.cingulata	30	30	30	26	6	0	0	0	50	50	44	18
C.madrasensis	0	2	0	0	0	0	0	0	12	0	0	0
C.obtusa	30	46	40	30	6	2	0	12	58	50	50	20
H.conoidalis	4	6	6	10	0	0	0	0	6	16	8	16
L.melanostoma	14	14	10	6	2	0	0	0	6	8	10	16
L.scarba	16	14	12	6	6	0	0	0	10	10	12	16
M.meretrix	12	6	8	10	0	0	0	0	16	12	12	10
M.ovum	12	4	8	8	0	0	0	0	10	10	12	10
N.violacea	8	8	12	6	2	0	0	12	14	10	26	6
O.gibbosa	8	16	12	12	0	0	0	0	0	12	14	2
R.bulbosa	4	2	2	0	0	0	0	2	8	8	12	16
T.attenuata	6	8	16	6	0	6	0	16	8	8	6	10
T.duplicata	4	8	10	6	0	0	0	0	8	8	4	10
T.telescopium	26	12	10	0	0	0	12	16	18	18	26	20

Table: 73. Monthly variations of molluscs in site I during 2005-06

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
B.granulata	2	4	0	0	0	0	4	8	10	10	4	8
B.spinosa	4	4	4	0	0	0	0	0	10	6	4	4
B.tuberculata	4	4	2	4	0	0	0	0	6	4	6	4
C.cingulata	40	32	22	0	0	0	0	40	50	40	44	38
C.madrasensis	0	0	0	0	0	0	0	0	0	6	0	3
C.obtusa	28	20	20	0	0	0	0	36	38	30	32	22
H.conoidalis	2	8	8	10	0	0	0	0	10	12	16	12
L.melanostoma	8	2	6	10	0	0	0	0	20	18	20	8
L.scarba	8	0	8	12	0	0	0	0	28	16	22	10
M.meretrix	32	24	36	48	0	0	0	0	42	40	48	28
M.ovum	22	24	32	36	0	0	0	0	36	42	46	20
N.violacea	52	46	40	32	0	0	0	0	54	68	80	76
O.gibbosa	0	12	10	0	0	0	0	0	20	12	12	8
R.bulbosa	0	4	2	2	0	0	0	0	2	8	8	6
T.attenuata	10	8	14	6	4	4	0	0	20	22	20	4
T.duplicata	6	6	14	8	2	4	0	0	14	14	18	0
T.telescopium	70	70	58	62	0	0	0	0	92	98	78	110

Table: 74. Monthly variations of molluscs in site II during 2004-05

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
B.spinosa	10	8	8	0	0	0	2	2	16	12	14	6
C.madrasensis	0	0	0	0	0	0	0	0	2	2	0	2
L.scarba	2	4	0	8	0	0	0	0	18	22	12	8
M.meretrix	6	4	4	8	0	0	0	0	6	4	10	4
N.violacea	28	40	42	0	0	0	0	46	48	40	52	20
O.gibbosa	0	6	10	0	0	0	0	0	18	12	10	2
R.bulbosa	0	2	0	4	0	0	0	0	0	4	2	2
P.globossa	0	2	0	0	4	12	16	10	0	8	0	0
T.telescopium	8	14	12	12	0	0	0	0	14	16	28	4

Table: 75. Monthly variations of molluscs in site II during 2005-06

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
L.melanostoma	12	16	12	8	0	0	0	0	18	20	16	16
L.scarba	14	22	10	8	0	0	0	0	12	20	22	12
M.meretrix	0	0	12	0	6	0	0	8	12	6	8	0
M.tribulus	0	0	0	0	0	0	0	0	0	0	0	2
N.violacea	10	16	0	0	0	0	0	0	18	10	12	12
P.globossa	0	0	0	0	6	8	12	18	8	0	0	0
T.brenneus	0	0	0	0	0	0	0	3	2	0	12	1

Table: 76. Monthly variations of molluscs in site III during 2004-05

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
L.melanostoma	10	16	8	8	0	0	0	4	16	22	18	14
L.scarba	16	16	4	6	0	0	0	0	24	22	22	12
M.meretrix	4	4	8	0	4	0	0	2	16	18	14	2
M.tribulus	0	0	0	0	0	0	0	0	0	1	0	0
N.violacea	4	2	6	0	0	6	22	0	12	10	14	16
P.globossa	0	0	0	0	12	12	18	22	20	0	0	03
T.brenneus	3	6	2	2	4	0	0	0	14	10	4	9

Table: 77. Monthly variations of molluscs in site III during 2005-06

Species	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
B.spinosa	2	4	4	6	0	0	0	2	4	4	6	10
C.madrasensis	6	12	4	0	0	0	0	0	4	10	2	10
L.scarba	8	12	4	6	8	0	0	0	16	20	16	2
M.meretrix	12	4	10	6	0	0	0	0	18	12	14	6
N.violacea	12	20	22	26	0	0	0	6	26	20	24	18
O.gibbosa	8	6	10	12	0	0	0	0	0	12	14	2
R.bulbosa	4	2	2	0	0	0	0	2	4	2	8	2
P.globossa	0	2	0	0	4	12	16	10	0	8	0	4
T.telescopium	10	12	18	8	0	2	0	10	8	18	20	8

Table: 78. ANOVA of seasonal variation of zooplankton composition in site I

Species	MS effect	MS error	F(df1,2)2,6	p-level
		2004-05		
A.major	109177	6323.444	17.26543	0.000831
A.gracilis	87249	6591	13.2376	0.002087
C.pauper	39145.75	2550.306	15.34943	0.001258
D.parvus	33466.33	1129.556	29.62788	0.00011
P.parvus	15276	1481.778	10.30924	0.0047
P.aurivelli	30861	3130.889	9.856945	0.005404
C.scutifer	214649.3	15591.22	13.76732	0.001828
M.leuckarti	53171.58	1607.972	33.06748	7.13E-05
O.bravicornis	4204.333	342.5555	12.27343	0.002683
O.similis	6566.333	774.1111	8.482417	0.008499
E.alcifrons	11089	1235.444	8.975718	0.007186
T.philetaerus	85.33334	3.555556	24	0.000247
S.minor	2359.75	452.3055	5.217159	0.031299
L.hanseni	3729.333	735.5555	5.070091	0.033522
P.indicus	39622.33	2022.111	19.59454	0.000526
M.dobsoni	30533.58	727.5278	41.96896	2.74E-05
S.inflatta	18416.33	1490.111	12.35903	0.002622
S.lanatum	44726.33	2158.444	20.72156	0.000428
M.meretrix	10545.75	3961.639	2.661967	0.123541
T.telescopium	3704.083	2112.972	1.75302	0.227537
		2005-06		
A.major	156528.6	19325.75	8.099483	0.009725
A.gracilis	97706.34	12981.11	7.526808	0.011989
C.pauper	16033.33	7870.333	2.037186	0.186293
D.parvus	2926.083	4031.167	0.725865	0.510205
P.parvus	8328.25	2508.194	3.320416	0.083161
P.aurivelli	11158.33	3473.111	3.212778	0.088513
C.scutifer	95633.34	41821.45	2.286706	0.157395
M.leuckarti	6075	8961.223	0.677921	0.531811
O.bravicornis	5582.333	2126.889	2.624647	0.12648
O.similis	1094.333	975.8889	1.121371	0.367423
E.alcifrons	3891	1731.778	2.246824	0.161625
T.philetaerus	56.33333	7.777778	7.242857	0.01335
S.minor	1933.583	486.4167	3.975158	0.057915
L.hanseni	3605.333	1560.111	2.310946	0.15489
P.indicus	12709.33	6834.667	1.85954	0.210883
M.dobsoni	472.75	8516.973	0.055507	0.946327
S.inflatta	727.5833	11066.39	0.065747	0.936813
S.lanatum	14732.33	19804.67	0.743882	0.502364
M.meretrix	4153.083	2106.083	1.971946	0.194894
T.telescopium	2679.083	2563.861	1.044941	0.390769

Table: 79. ANOVA of seasonal variation of zooplankton composition in site II

Species	MS effect	MS error	F(df1,2)2,6	p-level
2004-05				
A.major	4034.333	1054.889	3.824415	0.062786
A.gracilis	757.75	104.9722	7.218576	0.013475
C.pauper	932.3333	107.7778	8.650516	0.008021
D.parvus	766.3333	82.88889	9.245308	0.006573
P.parvus	514.5833	99.08334	5.19344	0.031645
P.aurivelli	588.0833	66.75	8.810237	0.007597
C.scutifer	3077.333	452.5555	6.799902	0.015872
M.leuckarti	217.3333	54.33333	4	0.057157
O.bravicornis	80.33334	62	1.295699	0.320243
O.similis	679	27.77778	24.444	0.00023
E.alcifrons	129.3333	22.22222	5.82	0.023872
T.philetaerus	21.33333	2.666667	8	0.010078
S.minor	139	19.33333	7.189655	0.013625
L.hanseni	784.3333	33.11111	23.68792	0.00026
P.indicus	453	31.77778	14.25525	0.001623
M.dobsoni	1129.333	74.22222	15.21557	0.001297
S.inflatta	466.3333	45.22222	10.31204	0.004696
S.lanatum	1174.333	86.44444	13.58483	0.001912
M.meretrix	177.3333	38.22222	4.639535	0.041238
T.telescopium	67	16.66667	4.02	0.056556
2005-06				
A.major	2300.333	1108.667	2.074865	0.181537
A.gracilis	577	110.1111	5.240161	0.030968
C.pauper	580.3333	118.5556	4.895033	0.036426
D.parvus	801.3333	36.88889	21.72289	0.000359
P.parvus	517.3333	48.44444	10.6789	0.004206
P.aurivelli	444.3333	86.88889	5.113811	0.032842
C.scutifer	1812.333	482.1111	3.759161	0.06505
M.leuckarti	261.3333	92	2.84058	0.110578
O.bravicornis	60.33333	47.77778	1.262791	0.328555
O.similis	432.3333	118.5556	3.646673	0.06919
E.alcifrons	105.3333	135.5556	0.777049	0.488311
T.philetaerus	21.33333	11.55556	1.846154	0.212892
S.minor	259	121.2222	2.136572	0.174064
L.hanseni	666.3333	90.44444	7.367322	0.012731
P.indicus	466.3333	89.11111	5.233167	0.031068
M.dobsoni	690.3333	199.3333	3.463211	0.076658
S.inflatta	499	92.77778	5.378443	0.029064
S.lanatum	724	317.3333	2.281512	0.157938
M.meretrix	65.33334	58.22222	1.122137	0.367198
T.telescopium	44.33333	20.22222	2.192308	0.167635

Table: 80. ANOVA of seasonal variation of zooplankton compositions in site III

Species	MS effect	MS error	F(df1,2)2,6	p-level
		2004-05		
A.major	152080.3	8360.333	18.1907	0.000689
A.gracilis	70114.34	6357.222	11.02908	0.003796
C.pauper	11090.33	1029.556	10.77196	0.004092
D.parvus	9516	1873.889	5.078209	0.033395
P.parvus	8584.333	1071.333	8.012756	0.010032
P.aurivelli	14556	3155.111	4.613467	0.041771
C.scutifer	212276.3	33211.89	6.391577	0.01873
M.leuckarti	7254.333	3032.667	2.392064	0.146854
O.bravicornis	1332.333	275	4.844849	0.037315
O.similis	2552.333	1118.444	2.282038	0.157883
E.alcifrons	9222.333	2103.778	4.383701	0.046858
T.philetaerus	41.33333	124.4444	0.332143	0.725817
S.minor	1442.333	331.4445	4.351659	0.047626
L.hanseni	3084.333	889.2222	3.468574	0.076426
P.indicus	23922.33	3250.444	7.359712	0.012768
M.dobsoni	16884	29081.89	0.580568	0.57923
S.inflatta	9793	4590.444	2.133345	0.174446
S.lanatum	17620.33	5074.111	3.472595	0.076253
M.meretrix	900.3333	699.8889	1.286395	0.322567
T.telescopium	2400.333	1344.333	1.785519	0.222291
		2005-06		
A.major	27546.48	27148.83	1.014647	0.404835
A.gracilis	32335.96	8935.375	3.618869	0.075976
C.pauper	3836.318	1968.375	1.948977	0.204395
D.parvus	5906.621	1109.708	5.322679	0.03389
P.parvus	4424.758	1080.083	4.096682	0.059568
P.aurivelli	10414.82	1657.75	6.282502	0.0229
C.scutifer	71703.82	32447.5	2.209841	0.172154
M.leuckarti	9116.621	1912.208	4.767588	0.043323
O.bravicornis	412.9849	360.2083	1.146517	0.364911
O.similis	1556.864	637.875	2.440703	0.148767
E.alcifrons	5324.03	1143.083	4.657605	0.045567
T.philetaerus	57.75758	4.833333	11.94984	0.003956
S.minor	516.4849	668.3333	0.772795	0.493343
L.hanseni	1876.621	1033.208	1.816305	0.223692
P.indicus	10872.48	3418.333	3.180639	0.096291
M.dobsoni	210.6667	477.3333	0.441341	0.657936
S.inflatta	11052.26	4888.208	2.261004	0.166596
S.lanatum	8473.758	7340.833	1.154332	0.362702
M.meretrix	885.1212	920.0833	0.962001	0.422292
T.telescopium	156.7576	2400.083	0.065313	0.937268

Table: 81. ANOVA of seasonal variation of crab composition in site I

Species	MS effect	MS error	F(df1,2)2,6	p-level
2004-05				
C. feriatus	101.4848	31.83333	3.188006	0.095897
C. lucifer	103.6667	18.08333	5.732719	0.02853
D.intermedia	1.272727	0.5	2.545455	0.13947
D.myctiroides	4.484848	4.333333	1.034965	0.39834
G.annulipes	1181.53	320.7083	3.684127	0.073428
M.messor	2.090909	4.75	0.440191	0.658617
S.granulata	4.363636	3	1.454545	0.289205
S.lenatum	1.939394	1.333333	1.454545	0.289205
S.serrata	10280.36	3274	3.140001	0.098502
S.taeniolata	30.12121	1.583333	19.02392	0.000911
U.acuta	5726.318	163.875	34.94321	0.000111
C. feriatus	7377.485	314.0833	23.48894	0.000448
C. lucifer	4.363636	3	1.454545	0.289205
2005-06				
C. feriatus	81.43333	6.311111	12.90317	0.002273
C. lucifer	25.06667	0.651852	38.45454	3.9E-05
D.intermedia	8.4	2.133333	3.9375	0.059087
D.myctiroides	11.025	6.318518	1.744871	0.228876
G.annulipes	1515	39.74074	38.12209	4.04E-05
M.messor	16.4	1.540741	10.64423	0.00425
S.granulata	0.233333	0.355556	0.65625	0.541943
S.lenatum	0.233333	0.355556	0.65625	0.541943
S.serrata	3640.067	92.54074	39.33475	3.56E-05
S.taeniolata	1.166667	4.296297	0.271552	0.768224
U.acuta	2971.167	79.40741	37.41674	4.35E-05
C. feriatus	2504.767	63.94074	39.17325	3.62E-05
C. lucifer	0.233333	0.355556	0.65625	0.541943

Table: 82. ANOVA of seasonal variation of crab composition in site II

Species	MS effect	MS error	F(df1,2)2,6	p-level
2004-05				
D.myctiroides	9.590909	0.875	0.00511	9.590909
S.serrata	5678.455	5.75	987.5573	2.65E-10
S.taeniolata	64	5	12.8	0.003214
U.lactea	11122.62	21.70833	512.3665	3.6E-09
2005-06				
D.myctiroides	0.266667	1.274074	0.209302	0.814989
S.serrata	341.6	334.6074	1.020898	0.398486
S.taeniolata	2072.5	212.7407	9.741904	0.005603
U.lactea	4810.1	101.2741	47.49587	1.65E-05

Table: II. 83. ANOVA of seasonal variation of crab composition in site III

Species	MS effect	MS error	F(df1,2)2,6	p-level
2004-05				
D.myctiroides	46.25758	0.708333	65.30481	1.11E-05
S.serrata	2274.939	31.08333	73.1884	7.21E-06
S.taeniolata	1.030303	0.833333	1.236364	0.340503
U.acuta	1561.53	17.70833	88.18053	3.55E-06
U.lactea	1902.985	17.70833	107.4627	1.66E-06
2005-06				
D.myctiroides	22.93333	2.311111	9.923077	0.005293
S.serrata	2730.9	78.87407	34.62354	5.94E-05
U.lactea	2268.767	74.05185	30.63754	9.63E-05

Table: II. 84. ANOVA of seasonal variation of molluscan composition in site I

Species	MS effect	MS error	F(df1,2)2,6	p-level
2004-05				
B.spinosa	38.31818	9.875	3.880322	0.066384
B.tuberculata	38.12121	3.833333	9.944664	0.00677
C.cingulata	26.25758	0.708333	37.06952	9E-05
C.madrasensis	1032.439	268.7083	3.842231	0.067683
C.obtusa	4.363636	3	1.454545	0.289205
H.conoidalis	515.0303	179.3333	2.871916	0.114796
L.melanostoma	140.6667	6.833333	20.58537	0.000701
L.scarba	324.4394	4.708333	68.90748	9.06E-06
M.meretrix	422.3636	18.5	22.83047	0.000494
M.ovum	1953.03	41.83333	46.68598	3.88E-05
N.violacea	1612.439	22.70833	71.00651	8.09E-06
O.gibbosa	4122.985	69.70834	59.14622	1.61E-05
P.globossa	185.1667	20.70833	8.941649	0.009126
R.bulbosa	31.27273	4	7.818182	0.013123
T.attenuata	298.9849	6.708333	44.56917	4.6E-05
T.brenneus	165.4848	8.083333	20.47235	0.000714
T.duplicata	7748.667	39.83333	194.5272	1.65E-07
T.telescopium	7748.667	39.83333	194.5272	1.65E-07
2005-06				
B.spinosa	21.56667	3.318519	6.498884	0.017922
B.tuberculata	36.6	3.82963	9.55706	0.005942
C.cingulata	10.1	0.82963	12.17411	0.002756
C.madrasensis	1981.433	14.2	139.5376	1.68E-07
C.obtusa	14.45833	11.55556	1.251202	0.331545
H.conoidalis	2044.9	53.54074	38.19334	4.01E-05
L.melanostoma	101.7333	11.02222	9.229838	0.006606
L.scarba	113.4	6.911111	16.40836	0.000995
M.meretrix	127.5667	9.874074	12.91935	0.002264
M.ovum	225.6	35.4963	6.355593	0.019011
N.violacea	147.0667	16.65185	8.831851	0.007541
O.gibbosa	389.6667	433.5185	0.898847	0.440658
R.bulbosa	70.1	3.82963	18.30464	0.000674
T.attenuata	7.166667	29.07407	0.246497	0.786642
T.brenneus	49.06667	7.762963	6.320611	0.01929
T.duplicata	672.4	919.3185	0.731411	0.507775
T.telescopium	70.1	3.82963	18.30464	0.000674

Table: II. 85. ANOVA of seasonal variation of molluscan composition in site II

Species	MS effect	MS error	F(df1,2)2,6	p-level
		2004-05		
B.spinosa	144.8636	8.875	16.32266	0.001501
L.scarba	277.1667	10.70833	25.88327	0.000321
M.meretrix	46.98485	3.708333	12.67007	0.003315
N.violacea	1061.121	348.0833	3.048469	0.10372
O.gibbosa	156.1212	13.33333	11.70909	0.004204
P.globossa	108.7576	15.08333	7.210447	0.016209
R.bulbosa	3.954545	2.375	1.665072	0.248553
T.telescopium	333.5303	16.70833	19.96191	0.000777
		2005-06		
B.spinosa	21.4	1.874074	11.41897	0.003395
C.madrasensis	33.6	13.27407	2.53125	0.134218
L.scarba	202.9	10.42963	19.45419	0.00054
M.meretrix	185.6	7.940741	23.37313	0.000273
N.violacea	530.5	16.62963	31.90089	8.21E-05
O.gibbosa	86.4	19.31852	4.472393	0.044809
P.globossa	118.9	13.42963	8.853558	0.007486
R.bulbosa	15	3.296296	4.550562	0.043094
T.telescopium	136.9	28.65185	4.778051	0.038539

Table: II. 86. ANOVA of seasonal variation of molluscan composition in site III

Species	MS effect	MS error	F(df1,2)2,6	p-level
		2004-05		
L.melanostoma	301.0909	5	60.21818	1.51E-05
L.scarba	320.3182	21.375	14.98565	0.00197
M.meretrix	32.25758	22.20833	1.452499	0.289639
N.violacea	153.1667	27.70833	5.52782	0.031065
P.globossa	129.7576	15.83333	8.195215	0.011574
T.brenneus	20.6553	11.17708	1.848005	0.218882
		2005-06		
L.melanostoma	280.9	10.87407	25.83208	0.000187
L.scarba	442.1	14.16296	31.21522	8.95E-05
M.meretrix	209.9333	7.088889	29.61442	0.00011
N.violacea	48.93333	46.31111	1.056622	0.387086
P.globossa	284.6667	37.62963	7.56496	0.011819
T.brenneus	64.1	8.607408	7.447074	0.012353

Table: 87. Simple correlation data between physico-chemical parameters and zooplanktons of Site I during 2004-05

	AT	ST	DWT	DO	CO^2	Phos	pH	Sal
A.major	0.8417 p=.001	0.8066 p=.002	0.6345 p=.027	-0.786 p=.002	0.4291 p=.164	-0.7728 p=.003	0.8455 p=.001	0.4999 p=.098
A.gracilis	0.8614 p=.000	0.7287 p=.007	0.5917 p=.043	-0.7635 p=.004	0.517 p=.085	-0.7747 p=.003	0.8275 p=.001	0.4687 p=.124
C.pauper	0.8121 p=.001	0.7219 p=.008	0.5844 p=.046	-0.6413 p=.025	0.4282 p=.165	-0.7512 p=.005	0.83 p=.001	0.5377 p=.071
D.parvus	0.8993 p=.000	0.682 p=.015	0.7085 p=.010	-0.8575 p=.000	0.8057 p=.002	-0.7509 p=.005	0.6987 p=.011	0.4544 p=.138
P.parvus	0.9158 p=.000	0.7496 p=.005	0.7055 p=.010	-0.831 p=.001	0.6132 p=.034	-0.6938 p=.012	0.7319 p=.007	0.4624 p=.130
P.aurivelli	0.8793 p=.000	0.7446 p=.005	0.7328 p=.007	-0.8339 p=.001	0.728 p=.007	-0.6904 p=.013	0.6695 p=.017	0.4701 p=.123
C.scutifer	0.8932 p=.000	0.6918 p=.013	0.6197 p=.032	-0.8466 p=.001	0.6361 p=.026	-0.7661 p=.004	0.7501 p=.005	0.4841 p=.111
M.leuckarti	0.8989 p=.000	0.6758 p=.016	0.7015 p=.011	-0.8868 p=.000	0.8353 p=.001	-0.714 p=.009	0.7221 p=.008	0.3906 p=.209
O.bravicornis	0.8942 p=.000	0.7414 p=.006	0.64 p=.025	-0.7663 p=.004	0.6146 p=.033	-0.7195 p=.008	0.6609 p=.019	0.5928 p=.042
O.similis	0.8174 p=.001	0.6801 p=.015	0.7393 p=.006	-0.8195 p=.001	0.8064 p=.002	-0.702 p=.011	0.6471 p=.023	0.3969 p=.201
E.alcifrons	0.8686 p=.000	0.7246 p=.008	0.7247 p=.008	-0.8419 p=.001	0.6507 p=.022	-0.7139 p=.009	0.7103 p=.010	0.4271 p=.166
T.philetaerus	-0.7927 p=.002	-0.757 p=.004	-0.7553 p=.005	0.6152 p=.033	-0.4307 p=.162	0.8915 p=.000	-0.8022 p=.002	-0.6613 p=.019
S.minor	0.8069 p=.002	0.7892 p=.002	0.6026 p=.038	-0.6872 p=.014	0.5097 p=.090	-0.7071 p=.010	0.6322 p=.027	0.6518 p=.022
Lhanseni	0.8097 p=.001	0.652 p=.022	0.707 p=.010	-0.6904 p=.013	0.7056 p=.010	-0.7143 p=.009	0.5499 p=.064	0.5662 p=.055
P.indicus	0.9298 p=.000	0.717 p=.009	0.7583 p=.004	-0.8787 p=.000	0.7645 p=.004	-0.7649 p=.004	0.7373 p=.006	0.4642 p=.128
M.dobsoni	0.7895 p=.002	0.437 p=.155	0.5479 p=.065	-0.7498 p=.005	0.8463 p=.001	-0.585 p=.046	0.5185 p=.084	0.3356 p=.286
S.enflata	0.5296 p=.077	0.1245 p=.700	0.2928 p=.356	-0.406 p=.190	0.5842 p=.046	-0.3605 p=.250	0.2807 p=.377	0.1752 p=.586
S.lanatum	0.8341 p=.001	0.4584 p=.134	0.5199 p=.083	-0.6197 p=.032	0.5794 p=.048	-0.6114 p=.035	0.5658 p=.055	0.4466 p=.146

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 88. Simple correlation data between physico-chemical parameters and zooplanktons of site I during 2004-05

	AT	ST	DWT	DO	CO^2	Phos	pH	Sal
A.major	-0.3223	-0.4778	-0.4504	0.5512	-0.8803	0.2878	-0.2561	-0.5715
	p=.307	p=.116	p=.142	p=.063	p=.000	p=.364	p=.422	p=.052
	-0.3093	-0.4668	-0.4976	0.5782	-0.8521	0.3393	-0.2473	-0.5938
A.gracilis	p=.328	p=.126	p=.100	p=.049	p=.000	p=.281	p=.438	p=.042
	-0.0068	-0.042	-0.1355	0.121	-0.4873	-0.0347	0.1638	-0.1071
C.pauper	p=.983	p=.897	p=.674	p=.708	p=.108	p=.915	p=.611	p=.740
	-0.1897	-0.078	-0.0144	0.2986	-0.5386	0.1482	-0.1012	-0.2261
	p=.555	p=.810	p=.965	p=.346	p=.071	p=.646	p=.754	p=.480
D.parvus	-0.1752	-0.2583	-0.238	0.242	-0.6545	0.132	-0.0727	-0.2097
	p=.586	p=.418	p=.456	p=.449	p=.021	p=.683	p=.822	p=.513
P.parvus	-0.4727	-0.5701	-0.287	0.5935	-0.7951	0.3435	-0.4877	-0.4598
	p=.121	p=.053	p=.366	p=.042	p=.002	p=.274	p=.108	p=.133
P.aurivelli	-0.3571	-0.3292	-0.1899	0.4136	-0.767	0.2408	-0.2769	-0.3681
	p=.255	p=.296	p=.554	p=.181	p=.004	p=.451	p=.384	p=.239
	0.0201	0.0921	-0.0148	0.1106	-0.3507	-0.0446	0.1703	-0.0685
C.scutifer	p=.951	p=.776	p=.963	p=.732	p=.264	p=.890	p=.597	p=.832
	0.0263	-0.0252	-0.0603	-0.0011	-0.3889	-0.1055	0.2451	0.0014
M.leuckarti	p=.935	p=.938	p=.852	p=.997	p=.212	p=.744	p=.443	p=.997
	-0.2523	-0.1455	0.0964	0.2795	-0.6093	0.0117	-0.2023	-0.121
O.bravicornis	p=.429	p=.652	p=.766	p=.379	p=.035	p=.971	p=.528	p=.708
	-0.4444	-0.3372	-0.138	0.4141	-0.6991	0.3584	-0.3422	-0.3195
O.similis	p=.148	p=.284	p=.669	p=.181	p=.011	p=.253	p=.276	p=.311
	-0.4033	-0.2742	-0.2643	0.3958	0.1182	0.4941	-0.4186	-0.4135
E.alcifrons	p=.194	p=.389	p=.406	p=.203	p=.714	p=.103	p=.176	p=.182
	-0.1673	-0.1428	0.02	0.1098	-0.5163	0.0231	0.011	-0.0162
	p=.603	p=.658	p=.951	p=.734	p=.086	p=.943	p=.973	p=.960
T.philetaerus	-0.1764	-0.2784	-0.2163	0.2334	-0.6516	0.0213	-0.0875	-0.159
	p=.583	p=.381	p=.499	p=.465	p=.022	p=.948	p=.787	p=.622
S.minor	-0.3371	-0.3576	-0.2003	0.4362	-0.766	0.1676	-0.2951	-0.3324
	p=.284	p=.254	p=.533	p=.156	p=.004	p=.603	p=.352	p=.291
	0.0714	-0.1034	-0.2407	0.2065	-0.3977	-0.1334	0.0362	-0.1712
Lhanseni	p=.825	p=.749	p=.451	p=.520	p=.200	p=.679	p=.911	p=.595
	0.1531	-0.0567	-0.1763	0.0607	-0.3333	-0.2374	0.1281	-0.1002
P.indicus	p=.635	p=.861	p=.584	p=.851	p=.290	p=.458	p=.692	p=.757
	0.0818	-0.1977	-0.337	0.1292	-0.5251	-0.2156	0.103	-0.1405
M.dobsoni	-0.3223	-0.4778	-0.4504	0.5512	-0.8803	0.2878	-0.2561	-0.5715
	p=.307	p=.116	p=.142	p=.063	p=.000	p=.364	p=.422	p=.052
S.enflata	-0.3093	-0.4668	-0.4976	0.5782	-0.8521	0.3393	-0.2473	-0.5938
	p=.328	p=.126	p=.100	p=.049	p=.000	p=.281	p=.438	p=.042
S.lanatum	-0.0068	-0.042	-0.1355	0.121	-0.4873	-0.0347	0.1638	-0.1071
	p=.983	p=.897	p=.674	p=.708	p=.108	p=.915	p=.611	p=.740

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 89. Simple correlation data between physico-chemical parameters and zooplanktons of site II during 2004-05

	AT	ST	DWT	DO	CO^2	Phos	pH	Sal
A.major	0.1049	0.1017	0.0466	-0.4653	0.5074	-0.5657	0.2839	0.612
	p=.746	p=.753	p=.886	p=.127	p=.092	p=.055	p=.371	p=.034
	0.3179	0.2138	0.3519	-0.6788	0.6608	-0.6678	0.2832	0.5772
A.gracilis	p=.314	p=.505	p=.262	p=.015	p=.019	p=.018	p=.372	p=.049
	0.3863	0.2903	0.3083	-0.6911	0.5778	-0.7467	0.4798	0.6154
C.pauper	p=.215	p=.360	p=.330	p=.013	p=.049	p=.005	p=.114	p=.033
	0.4308	0.2962	0.4349	-0.7722	0.7005	-0.7433	0.3996	0.5581
	p=.162	p=.350	p=.158	p=.003	p=.011	p=.006	p=.198	p=.059
D.parvus	0.1645	0.0656	0.2374	-0.6024	0.5524	-0.5833	0.2653	0.5092
	p=.609	p=.839	p=.458	p=.038	p=.063	p=.047	p=.405	p=.091
P.parvus	0.3523	0.2789	0.2858	-0.6506	0.6234	-0.7696	0.4735	0.5927
	p=.261	p=.380	p=.368	p=.022	p=.030	p=.003	p=.120	p=.042
P.aurivelli	0.2971	0.2325	0.3242	-0.6294	0.6683	-0.6745	0.2718	0.6462
	p=.348	p=.467	p=.304	p=.028	p=.018	p=.016	p=.393	p=.023
	0.1909	-0.0054	0.2367	-0.6775	0.5743	-0.4936	0.3649	0.1322
C.scutifer	p=.552	p=.987	p=.459	p=.015	p=.051	p=.103	p=.243	p=.682
	0.0086	-0.1226	-0.4034	-0.3231	0.4552	-0.2569	0.132	0.3132
M.leuckarti	p=.979	p=.704	p=.193	p=.306	p=.137	p=.420	p=.683	p=.322
	0.6103	0.4592	0.3901	-0.7899	0.6986	-0.8255	0.5424	0.593
O.bravicornis	p=.035	p=.133	p=.210	p=.002	p=.011	p=.001	p=.068	p=.042
	0.2468	0.1842	0.0992	-0.6324	0.6438	-0.5857	0.2821	0.5328
O.similis	p=.439	p=.567	p=.759	p=.027	p=.024	p=.045	p=.374	p=.074
	-0.5207	-0.4832	-0.2957	0.544	-0.4034	0.8266	-0.7399	-0.4185
E.alcifrons	p=.083	p=.112	p=.351	p=.067	p=.193	p=.001	p=.006	p=.176
	0.5188	0.5104	0.1635	-0.5785	0.4734	-0.6918	0.5237	0.7292
	p=.084	p=.090	p=.612	p=.049	p=.120	p=.013	p=.081	p=.007
T.philetaerus	0.6489	0.4338	0.4649	-0.8762	0.6537	-0.819	0.6432	0.4575
	p=.022	p=.159	p=.128	p=.000	p=.021	p=.001	p=.024	p=.135
S.minor	0.599	0.4952	0.4615	-0.7234	0.6682	-0.8113	0.48	0.6056
	p=.040	p=.102	p=.131	p=.008	p=.018	p=.001	p=.114	p=.037
	0.6669	0.4862	0.5123	-0.8321	0.566	-0.8117	0.6685	0.4669
Lhanseni	p=.018	p=.109	p=.089	p=.001	p=.055	p=.001	p=.017	p=.126
	0.5195	0.4806	0.3258	-0.7014	0.5919	-0.7738	0.5176	0.7205
P.indicus	p=.083	p=.114	p=.301	p=.011	p=.043	p=.003	p=.085	p=.008
	0.6452	0.5351	0.449	-0.78	0.5834	-0.8146	0.6004	0.6121
M.dobsoni	p=.023	p=.073	p=.143	p=.003	p=.046	p=.001	p=.039	p=.034
	0.1049	0.1017	0.0466	-0.4653	0.5074	-0.5657	0.2839	0.612
S.enflata	p=.746	p=.753	p=.886	p=.127	p=.092	p=.055	p=.371	p=.034
	0.3179	0.2138	0.3519	-0.6788	0.6608	-0.6678	0.2832	0.5772
S.lanatum	p=.314	p=.505	p=.262	p=.015	p=.019	p=.018	p=.372	p=.049
	0.3863	0.2903	0.3083	-0.6911	0.5778	-0.7467	0.4798	0.6154

Marked correlations are significant at $p < .05000$

N=12 (Case wise deletion of missing data)

Table: 90. Simple correlation data between physico-chemical parameters and zooplanktons of site II during 2005-06

	AT	ST	DWT	DO	CO^2	Phos	pH	Sal
A.major	-0.4829	-0.5119	-0.4321	0.6194	-0.6346	0.3925	-0.3856	-0.3853
	p=.112	p=.089	p=.161	p=.032	p=.027	p=.207	p=.216	p=.216
	-0.6526	-0.6258	-0.528	0.6221	-0.6827	0.5943	-0.3316	-0.669
A.gracilis	p=.021	p=.030	p=.078	p=.031	p=.014	p=.042	p=.292	p=.017
	-0.6267	-0.5633	-0.4985	0.6381	-0.7926	0.5663	-0.2569	-0.6602
C.pauper	p=.029	p=.057	p=.099	p=.026	p=.002	p=.055	p=.420	p=.019
	-0.6118	-0.7119	-0.6826	0.7377	-0.8873	0.6123	-0.309	-0.6713
	p=.035	p=.009	p=.014	p=.006	p=.000	p=.034	p=.328	p=.017
D.parvus	-0.6708	-0.7325	-0.6408	0.7761	-0.7463	0.7031	-0.4272	-0.6116
	p=.017	p=.007	p=.025	p=.003	p=.005	p=.011	p=.166	p=.035
P.parvus	-0.4816	-0.5314	-0.4512	0.6169	-0.8161	0.3869	-0.1612	-0.4405
	p=.113	p=.075	p=.141	p=.033	p=.001	p=.214	p=.617	p=.152
P.aurivelli	-0.4919	-0.5904	-0.5042	0.6546	-0.7069	0.411	-0.3964	-0.509
	p=.104	p=.043	p=.095	p=.021	p=.010	p=.184	p=.202	p=.091
	-0.4977	-0.5463	-0.621	0.5851	-0.1507	0.7407	-0.4859	-0.6505
C.scutifer	p=.100	p=.066	p=.031	p=.046	p=.640	p=.006	p=.109	p=.022
	-0.2694	-0.3621	-0.3961	0.5809	-0.6086	0.4152	-0.3071	-0.1759
M.leuckarti	p=.397	p=.247	p=.202	p=.048	p=.036	p=.180	p=.332	p=.584
	-0.3965	-0.4412	-0.439	0.5597	-0.8292	0.3109	-0.259	-0.4716
O.bravicornis	p=.202	p=.151	p=.153	p=.058	p=.001	p=.325	p=.416	p=.122
	-0.3308	-0.4203	-0.4156	0.5229	-0.3175	0.3599	-0.68	-0.2585
O.similis	p=.294	p=.174	p=.179	p=.081	p=.315	p=.251	p=.015	p=.417
	-0.3664	-0.3678	-0.3295	0.3105	-0.4621	0.3762	0.2061	-0.3329
E.alcifrons	p=.241	p=.240	p=.296	p=.326	p=.130	p=.228	p=.520	p=.290
	-0.0878	-0.0512	-0.0601	0.1712	-0.63	0.0122	0.431	-0.1375
	p=.786	p=.874	p=.853	p=.595	p=.028	p=.970	p=.162	p=.670
T.philetaerus	-0.4822	-0.5561	-0.5693	0.6546	-0.8902	0.4603	-0.3215	-0.548
	p=.112	p=.060	p=.053	p=.021	p=.000	p=.132	p=.308	p=.065
S.minor	-0.2781	-0.3126	-0.2582	0.3722	-0.7733	0.1499	0.0338	-0.3999
	p=.381	p=.323	p=.418	p=.233	p=.003	p=.642	p=.917	p=.198
	-0.5472	-0.5168	-0.5346	0.5861	-0.7501	0.5175	-0.3565	-0.6607
Lhanseni	p=.066	p=.085	p=.073	p=.045	p=.005	p=.085	p=.255	p=.019
	-0.3462	-0.3985	-0.3973	0.5375	-0.8894	0.2343	-0.0268	-0.3763
P.indicus	p=.270	p=.199	p=.201	p=.071	p=.000	p=.464	p=.934	p=.228
	-0.5404	-0.5546	-0.5786	0.6413	-0.6874	0.4651	-0.5179	-0.6161
M.dobsoni	p=.070	p=.061	p=.049	p=.025	p=.013	p=.128	p=.085	p=.033
	-0.4829	-0.5119	-0.4321	0.6194	-0.6346	0.3925	-0.3856	-0.3853
S.enflata	p=.112	p=.089	p=.161	p=.032	p=.027	p=.207	p=.216	p=.216
	-0.6526	-0.6258	-0.528	0.6221	-0.6827	0.5943	-0.3316	-0.669
S.lanatum	p=.021	p=.030	p=.078	p=.031	p=.014	p=.042	p=.292	p=.017
	-0.6267	-0.5633	-0.4985	0.6381	-0.7926	0.5663	-0.2569	-0.6602

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 91. Simple correlation data between physico-chemical parameters and zooplanktons of site III during 2004-05

	AT	ST	DWT	DO	CO^2	Phos	pH	Sal
A.major	0.6753	0.6191	0.194	-0.2171	0.1583	-0.5715	0.5002	0.2506
	p=.016	p=.032	p=.546	p=.498	p=.623	p=.052	p=.098	p=.432
	0.5641	0.5507	0.0815	-0.0983	0.0935	-0.4532	0.4945	0.3219
A.gracilis	p=.056	p=.063	p=.801	p=.761	p=.772	p=.139	p=.102	p=.308
	0.5145	0.4509	0.0978	-0.1464	0.101	-0.5961	0.5262	0.2901
C.pauper	p=.087	p=.141	p=.762	p=.650	p=.755	p=.041	p=.079	p=.360
	0.4322	0.3885	-0.0705	0.1567	-0.0106	-0.356	0.5848	-0.0037
	p=.161	p=.212	p=.828	p=.627	p=.974	p=.256	p=.046	p=.991
D.parvus	0.514	0.516	0.0379	0.015	0.0072	-0.3144	0.5502	0.1384
	p=.087	p=.086	p=.907	p=.963	p=.982	p=.320	p=.064	p=.668
P.parvus	0.396	0.3457	-0.0821	0.1589	-0.0389	-0.2604	0.5724	-0.0227
	p=.203	p=.271	p=.800	p=.622	p=.904	p=.414	p=.052	p=.944
P.aurivelli	0.6597	0.5912	0.2288	-0.0148	-0.0352	-0.4745	0.4831	-0.0869
	p=.020	p=.043	p=.474	p=.964	p=.914	p=.119	p=.112	p=.788
	0.1154	0.1201	-0.2937	0.3545	-0.1694	0.0262	0.599	-0.0075
C.scutifer	p=.721	p=.710	p=.354	p=.258	p=.599	p=.936	p=.040	p=.982
	0.5139	0.4701	0.0429	0.034	-0.1191	-0.3865	0.6405	-0.0076
M.leuckarti	p=.087	p=.123	p=.895	p=.916	p=.712	p=.215	p=.025	p=.981
	0.3679	0.3981	-0.195	0.1455	-0.0039	-0.1413	0.5842	0.0885
O.bravicornis	p=.239	p=.200	p=.544	p=.652	p=.990	p=.661	p=.046	p=.785
	0.4557	0.4171	0.0084	0.1506	-0.085	-0.2749	0.5209	-0.0888
O.similis	p=.137	p=.177	p=.979	p=.640	p=.793	p=.387	p=.082	p=.784
	-0.2025	-0.1163	-0.1115	-0.2572	0.1776	0.0856	-0.1319	0.6656
E.alcifrons	p=.528	p=.719	p=.730	p=.420	p=.581	p=.791	p=.683	p=.018
	0.6141	0.6194	0.0561	-0.2655	0.4291	-0.4026	0.5119	-0.0374
	p=.034	p=.032	p=.862	p=.404	p=.164	p=.194	p=.089	p=.908
T.philetaerus	0.6745	0.6757	0.1746	-0.2137	0.1437	-0.4274	0.3874	0.1636
	p=.016	p=.016	p=.587	p=.505	p=.656	p=.166	p=.213	p=.611
S.minor	0.5923	0.5677	0.0608	-0.0633	0.0954	-0.4271	0.5145	0.2185
	p=.042	p=.054	p=.851	p=.845	p=.768	p=.166	p=.087	p=.495
	-0.259	-0.3008	-0.1332	0.0748	-0.2161	0.2318	0.0405	-0.1835
Lhanseni	p=.416	p=.342	p=.680	p=.817	p=.500	p=.468	p=.901	p=.568
	0.4822	0.5119	0.4249	-0.5795	0.2782	-0.4288	-0.0863	0.4878
P.indicus	p=.112	p=.089	p=.168	p=.048	p=.381	p=.164	p=.790	p=.108
	0.559	0.5755	0.411	-0.5425	0.2372	-0.5125	0.0521	0.481
M.dobsoni	p=.059	p=.050	p=.184	p=.068	p=.458	p=.088	p=.872	p=.113
	0.6753	0.6191	0.194	-0.2171	0.1583	-0.5715	0.5002	0.2506
S.enflata	p=.016	p=.032	p=.546	p=.498	p=.623	p=.052	p=.098	p=.432
	0.5641	0.5507	0.0815	-0.0983	0.0935	-0.4532	0.4945	0.3219
S.lanatum	p=.056	p=.063	p=.801	p=.761	p=.772	p=.139	p=.102	p=.308
	0.5145	0.4509	0.0978	-0.1464	0.101	-0.5961	0.5262	0.2901

Marked correlations are significant at $p < .05000$

N=12 (Case wise deletion of missing data)

Table: 92. Simple correlation data between physico-chemical parameters and zooplanktons of site III during 2005-06

	AT	SST	DWT	DO	CO^2	Phos	pH	Sal
A.major	0.2823	0.1917	0.1873	0.0173	-0.3206	-0.2457	0.2357	0.2847
	p=.374	p=.551	p=.560	p=.957	p=.310	p=.441	p=.461	p=.370
	0.3061	0.0842	0.1142	0.0053	-0.3905	-0.2326	0.1255	0.1094
A.gracilis	p=.333	p=.795	p=.724	p=.987	p=.209	p=.467	p=.697	p=.735
	0.4458	0.4898	0.3811	-0.2725	-0.0571	-0.4249	0.1171	0.3117
C.pauper	p=.146	p=.106	p=.222	p=.391	p=.860	p=.169	p=.717	p=.324
	0.5055	0.3047	0.357	-0.2997	-0.1286	-0.3067	0.0247	0.211
	p=.094	p=.335	p=.255	p=.344	p=.691	p=.332	p=.939	p=.510
D.parvus	0.3068	0.0247	0.0738	0.0032	-0.3323	-0.1697	0.153	0.0273
	p=.332	p=.939	p=.820	p=.992	p=.291	p=.598	p=.635	p=.933
P.parvus	0.4809	0.2124	0.2567	-0.2553	-0.1131	-0.2005	0.0484	0.0893
	p=.113	p=.507	p=.421	p=.423	p=.726	p=.532	p=.881	p=.783
P.aurivelli	0.1809	0.0403	0.0483	0.1276	-0.4969	-0.245	0.1533	0.1105
	p=.574	p=.901	p=.882	p=.693	p=.100	p=.443	p=.634	p=.732
	0.5584	0.3416	0.3733	-0.5051	0.3082	-0.0888	0.079	0.0892
C.scutifer	p=.059	p=.277	p=.232	p=.094	p=.330	p=.784	p=.807	p=.783
	0.32	0.2926	0.1803	-0.115	-0.0708	-0.3238	0.2139	0.1034
M.leuckarti	p=.311	p=.356	p=.575	p=.722	p=.827	p=.304	p=.504	p=.749
	0.2536	0.06	0.1445	-0.0699	-0.2339	-0.1479	0.2163	0.0265
O.bravicornis	p=.426	p=.853	p=.654	p=.829	p=.464	p=.647	p=.500	p=.935
	0.3934	0.1156	0.1714	-0.1126	-0.2636	-0.2202	0.0852	0.0796
O.similis	p=.206	p=.720	p=.594	p=.727	p=.408	p=.492	p=.792	p=.806
	-0.0561	-0.0451	0.0864	0.065	-0.3209	-0.1094	0.2294	0.1724
E.alcifrons	p=.863	p=.889	p=.790	p=.841	p=.309	p=.735	p=.473	p=.592
	-0.0801	-0.1366	0.0378	0.2332	-0.4869	-0.0812	0.4507	0.1821
	p=.805	p=.672	p=.907	p=.466	p=.108	p=.802	p=.141	p=.571
T.philetaerus	-0.1976	-0.3024	-0.288	0.4966	-0.6568	-0.081	0.2658	-0.1284
	p=.538	p=.339	p=.364	p=.101	p=.020	p=.802	p=.404	p=.691
S.minor	0.224	0.0368	0.0688	0.0725	-0.4501	-0.2306	0.1286	0.0717
	p=.484	p=.910	p=.832	p=.823	p=.142	p=.471	p=.690	p=.825
	0.0021	0.0181	0.1163	0.0667	-0.3425	-0.1903	0.2881	0.215
L.hanseni	p=.995	p=.956	p=.719	p=.837	p=.276	p=.554	p=.364	p=.502
	-0.4601	-0.3417	-0.3657	0.6069	-0.6146	-0.0636	0.0978	-0.0699
P.indicus	p=.132	p=.277	p=.242	p=.036	p=.033	p=.844	p=.762	p=.829
	-0.4626	-0.2866	-0.4372	0.6269	-0.5042	-0.0557	0.0068	-0.1651
M.dobsoni	p=.130	p=.366	p=.155	p=.029	p=.095	p=.864	p=.983	p=.608
	0.2823	0.1917	0.1873	0.0173	-0.3206	-0.2457	0.2357	0.2847
S.enflata	p=.374	p=.551	p=.560	p=.957	p=.310	p=.441	p=.461	p=.370
	0.3061	0.0842	0.1142	0.0053	-0.3905	-0.2326	0.1255	0.1094
S.lanatum	p=.333	p=.795	p=.724	p=.987	p=.209	p=.467	p=.697	p=.735
	0.4458	0.4898	0.3811	-0.2725	-0.0571	-0.4249	0.1171	0.3117

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 93. Simple correlation data between physico-chemical parameters and crabs of site I during 2004-05

	AT	ST	DWT	DO	CO^2	Phos	pH	Sal
C. feriatus	0.5197 p=.083	0.034 p=.917	0.3716 p=.234	-0.41 p=.186	0.3489 p=.266	-0.5676 p=.054	0.4317 p=.161	0.0802 p=.804
C. lucifera	0.701 p=.011	0.1864 p=.562	0.4823 p=.112	-0.5724 p=.052	0.4563 p=.136	-0.5524 p=.063	0.4525 p=.140	0.1717 p=.594
D. intermedia	0.4917 p=.104	0.1491 p=.644	0.5312 p=.076	-0.6587 p=.020	0.8391 p=.001	-0.3405 p=.279	0.2966 p=.349	-0.0414 p=.898
D.myctiroides	0.3511 p=.263	-0.0563 p=.862	-0.0562 p=.862	-0.4046 p=.192	0.2129 p=.506	-0.5092 p=.091	0.1325 p=.681	0.3445 p=.273
G. annulipes	0.4164 p=.178	0.2696 p=.397	0.2345 p=.463	-0.2543 p=.425	-0.0438 p=.892	-0.5232 p=.081	0.4024 p=.195	0.5091 p=.091
M.messor	-0.1601 p=.619	-0.1456 p=.652	-0.22 p=.492	0.0681 p=.833	-0.2553 p=.423	-0.107 p=.741	-0.2898 p=.361	0.2671 p=.401
S.granulata	-0.0368 p=.910	0.1005 p=.756	0.0143 p=.965	0.0814 p=.802	-0.2096 p=.513	-0.1098 p=.734	-0.0182 p=.955	-0.0279 p=.931
S. lanatum	-0.0368 p=.910	0.1005 p=.756	0.0143 p=.965	0.1806 p=.574	-0.2474 p=.438	0.01 p=.975	0.4182 p=.176	0.0559 p=.863
Scylla serrata	0.1091 p=.736	0.1752 p=.586	0.1162 p=.719	0.096 p=.767	-0.3889 p=.211	-0.2215 p=.489	0.2256 p=.481	0.3731 p=.232
S.taeniolata	0.206 p=.521	0.2535 p=.427	0.1272 p=.694	-0.1002 p=.757	-0.2027 p=.528	-0.2616 p=.411	0.4605 p=.132	0.144 p=.655
Uca acuta acuta	0.8135 p=.001	0.5267 p=.079	0.5711 p=.052	-0.5962 p=.041	0.3247 p=.303	-0.6558 p=.021	0.6772 p=.016	0.3712 p=.235
Uca lactea	0.7612 p=.004	0.5169 p=.085	0.4947 p=.102	-0.5508 p=.063	0.2437 p=.445	-0.537 p=.072	0.6983 p=.012	0.2511 p=.431

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 94. Simple correlation data between physico-chemical parameters and crabs of site I during 2005-06

	AT	ST	DWT	DO	CO^2	Phos	pH	Sal
C. feriatus	0.8661 p=.000	0.5853 p=.046	0.3352 p=.287	-0.7799 p=.003	0.5403 p=.070	-0.7642 p=.004	0.8292 p=.001	0.6362 p=.026
C. lucifera	0.7389 p=.006	0.844 p=.001	0.4475 p=.145	-0.7367 p=.006	0.6654 p=.018	-0.6221 p=.031	0.818 p=.001	0.7428 p=.006
D. intermedia	0.4081 p=.188	0.5895 p=.044	0.614 p=.034	-0.7555 p=.004	0.898 p=.000	-0.4858 p=.109	0.4174 p=.177	0.7823 p=.003
D.myctiroides	0.1267 p=.695	0.1469 p=.649	0.1476 p=.647	-0.5476 p=.065	0.2959 p=.350	-0.4507 p=.141	0.2532 p=.427	0.5099 p=.090
G. annulipes	0.8517 p=.000	0.7871 p=.002	0.747 p=.005	-0.869 p=.000	0.7039 p=.011	-0.6688 p=.017	0.8087 p=.001	0.8205 p=.001
M.messor	0.7285 p=.007	0.678 p=.015	0.4085 p=.187	-0.7742 p=.003	0.7234 p=.008	-0.6392 p=.025	0.801 p=.002	0.7087 p=.010
S.granulata	0.3507 p=.264	0.3079 p=.330	-0.0291 p=.928	-0.2601 p=.414	0.6113 p=.035	-0.2109 p=.511	0.3148 p=.319	0.3164 p=.316
S. lanatum	0.3507 p=.264	0.4398 p=.153	-0.0291 p=.928	-0.095 p=.769	0.0679 p=.834	-0.1753 p=.586	0.3148 p=.319	0.0492 p=.879
Scylla serrata	0.7222 p=.008	0.704 p=.011	0.4257 p=.168	-0.7511 p=.005	0.5472 p=.066	-0.676 p=.016	0.8232 p=.001	0.6916 p=.013
S.taeniolata	0.2776 p=.382	-0 p=1.00	-0.34 p=.280	-0.123 p=.703	0.206 p=.521	-0.2308 p=.470	0.3259 p=.301	0.1736 p=.589
U. acuta acuta	0.6579	0.6967	0.5233	-0.7865	0.5786	-0.6574	0.7792	0.7131
	p=.020	p=.012	p=.081	p=.002	p=.049	p=.020	p=.003	p=.009
U. lactea	0.7616 p=.004	0.6727 p=.017	0.5221 p=.082	-0.7649 p=.004	0.4671 p=.126	-0.7023 p=.011	0.8098 p=.001	0.6791 p=.015

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 95. Simple correlation data between physico-chemical parameters and crabs of site II

	AT	ST	DWT	DO	CO^2	Phos	pH	Sal
				2004-05				
D.myctiroides	0.3823 p=.220	-0.2188 p=.494	0.156 p=.628	-0.7673 p=.004	0.5505 p=.064	-0.5377 p=.071	0.2871 p=.365	-0.069 p=.831
S.serrata	0.6963 p=.012	0.5818 p=.047	0.1575 p=.625	-0.6105 p=.035	0.4418 p=.150	-0.6668 p=.018	0.5476 p=.065	0.432 p=.161
S.taeniolata	0.7736 p=.003	0.3649 p=.243	0.2643 p=.406	-0.7912 p=.002	0.7891 p=.002	-0.6019 p=.038	0.3129 p=.322	0.1409 p=.662
U. lactea	0.6664 p=.018	0.5427 p=.068	0.1582 p=.623	-0.614 p=.034	0.466 p=.127	-0.7004 p=.011	0.5567 p=.060	0.4265 p=.167
				2005-06				
D.myctiroides	-0.1117 p=.730	0.1187 p=.713	0.295 p=.352	-0.1703 p=.597	0.1915 p=.551	0.0251 p=.938	0.275 p=.387	0.0625 p=.847
S.serrata	0.2322 p=.468	0.2491 p=.435	0.2554 p=.423	-0.2236 p=.485	-0.1445 p=.654	-0.2123 p=.508	0.6973 p=.012	0.1637 p=.611
S.taeniolata	0.7665 p=.004	0.7887 p=.002	0.7986 p=.002	-0.8355 p=.001	0.7066 p=.010	-0.7823 p=.003	0.2202 p=.492	0.6098 p=.035
U. lactea	0.8416 p=.001	0.8045 p=.002	0.8007 p=.002	-0.8297 p=.001	0.3907 p=.209	-0.8109 p=.001	0.7027 p=.011	0.5701 p=.053

Marked correlations are
significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 96. Simple correlation data between physico-chemical parameters and crabs of site III

	AT	ST	DWT	DO	CO^2	Phos	pH	Sal
2004-05								
D.myctiroides	0.6826 p=.014	0.1677 p=.602	0.3501 p=.265	-0.7721 p=.003	0.8253 p=.001	-0.6599 p=.020	-0.1792 p=.577	0.0818 p=.800
P.pelagicus	-0.5014 p=.097	-0.3709 p=.235	-0.3322 p=.292	0.545 p=.067	-0.0312 p=.923	0.0646 p=.842	-0.1615 p=.616	-0.2076 p=.517
S.serrata	0.6613 p=.019	0.7048 p=.010	0.2686 p=.399	-0.441 p=.151	0.3652 p=.243	-0.5584 p=.059	0.3965 p=.202	0.248 p=.437
S.taeniolata	0.576 p=.050 0.5487	0.2978 p=.347 0.3898	0.3816 p=.221 0.2093	-0.2982 p=.346 -0.6366	0.1791 p=.578 0.6533	-0.5635 p=.056 -0.5454	-0.0848 p=.793 0.1271	0.0748 p=.817 0.2428
U.acuta	p=.065 0.5476	p=.210 0.4686	p=.514 0.1444	p=.026 -0.4996	p=.021 0.563	p=.067 -0.538	p=.694 0.2544	p=.447 0.2473
U. lactea	p=.065 0.6613	p=.124 0.7048	p=.654 0.2686	p=.098 -0.441	p=.057 0.3652	p=.071 -0.5584	p=.425 0.3965	p=.438 0.248
2005-06								
D.myctiroides	0.2403 p=.452	0.5993 p=.039	0.4048 p=.192	-0.4231 p=.171	0.5414 p=.069	-0.2037 p=.525	-0.2487 p=.436	0.2201 p=.492
S.serrata	0.8867 p=.000	0.7771 p=.003	0.7895 p=.002	-0.902 p=.000	0.5757 p=.050	-0.7018 p=.011	-0.1919 p=.550	0.6267 p=.029
S.taeniolata	0.1348 p=.676	0.1663 p=.606	0.1888 p=.557	-0.095 p=.769	-0.2432 p=.446	-0.1868 p=.561	-0.0469 p=.885	0.0368 p=.910
U.acuta	0.1348 p=.676	0.1663 p=.606	0.1888 p=.557	-0.095 p=.769	-0.2432 p=.446	-0.1868 p=.561	-0.0469 p=.885	0.0368 p=.910
U. lactea	0.8397 p=.001	0.7875 p=.002	0.8118 p=.001	-0.9083 p=.000	0.545 p=.067	-0.7102 p=.010	-0.2172 p=.498	0.6342 p=.027

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 97. Simple correlation data between physico-chemical parameters and molluscs of site I during 2004-05

	AT	SST	DWT	DO	CO^2	Phos	pH	Sal
B.granulata	-0.2008 p=.532	-0.1332 p=.680	-0.2089 p=.515	0.334 p=.289	-0.4255 p=.168	-0.1573 p=.625	0.0402 p=.901	0.2222 p=.488
B.spinosa	0.3689 p=.238	0.2876 p=.365	0.3484 p=.267	-0.1909 p=.552	-0.0316 p=.922	-0.3499 p=.265	0.6503 p=.022	0.0949 p=.769
B.tuberculata	0.6737 p=.016	0.549 p=.064	0.4185 p=.176	-0.3734 p=.232	0.0573 p=.860	-0.5809 p=.048	0.7643 p=.004	0.4777 p=.116
C.cingulata	0.3088 p=.329	0.1339 p=.678	0.1773 p=.581	-0.1724 p=.592	-0.1812 p=.573	-0.404 p=.193	0.4108 p=.185	0.2799 p=.378
C.madrasensis	-0.0368 p=.910	0.1005 p=.756	0.0143 p=.965	0.0814 p=.802	-0.2096 p=.513	-0.1098 p=.734	-0.0182 p=.955	-0.0279 p=.931
C.obtusa	0.2595 p=.415	0.1241 p=.701	0.1779 p=.580	-0.1275 p=.693	-0.1981 p=.537	-0.3618 p=.248	0.3447 p=.273	0.2993 p=.345
H.conoidalis	0.6573 p=.020	0.6712 p=.017	0.5441 p=.067	-0.4011 p=.196	0.155 p=.630	-0.5125 p=.088	0.6362 p=.026	0.5068 p=.093
L.melanostoma	0.4512 p=.141	0.5518 p=.063	0.3691 p=.238	-0.1101 p=.733	-0.2176 p=.497	-0.378 p=.226	0.6066 p=.036	0.409 p=.187
L.scabra	0.4182 p=.176	0.5498 p=.064	0.3733 p=.232	-0.066 p=.838	-0.2179 p=.496	-0.3224 p=.307	0.6299 p=.028	0.4092 p=.187
M.meretrix	0.7998 p=.002	0.72 p=.008	0.624 p=.030	-0.4504 p=.142	0.2289 p=.474	-0.6298 p=.028	0.7528 p=.005	0.5748 p=.051
M.ovum	0.7483 p=.005	0.693 p=.012	0.6108 p=.035	-0.4393 p=.153	0.1977 p=.538	-0.5966 p=.041	0.7156 p=.009	0.5156 p=.086
N.violacea	0.6808 p=.015	0.5274 p=.078	0.5024 p=.096	-0.4173 p=.177	0.0812 p=.802	-0.5773 p=.049	0.6882 p=.013	0.3659 p=.242
O.gibbosa	0.3637 p=.245	0.3469 p=.269	0.3967 p=.202	-0.2632 p=.408	0.0854 p=.792	-0.3069 p=.332	0.5999 p=.039	0.1278 p=.692
R.bulbosa	0.4168 p=.178	0.4434 p=.149	0.3325 p=.291	-0.2833 p=.372	-0.0148 p=.964	-0.3734 p=.232	0.3731 p=.232	0.2893 p=.362
T.atenuata	0.4823 p=.112	0.4669 p=.126	0.4538 p=.138	-0.2556 p=.423	-0.0779 p=.810	-0.305 p=.335	0.5913 p=.043	0.1534 p=.634
T.duplicata	0.614 p=.034	0.6067 p=.036	0.6131 p=.034	-0.357 p=.255	0.0757 p=.815	-0.3499 p=.265	0.6176 p=.032	0.2869 p=.366
T.telescopium	0.6996 p=.011	0.5519 p=.063	0.5113 p=.089	-0.429 p=.164	0.1717 p=.594	-0.6207 p=.031	0.7457 p=.005	0.4027 p=.194

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 98. Simple correlation data between physico-chemical parameters and molluscs of site I during 2005-06

	AT	SST	DWT	DO	FCO^2	Phos	pH	Sal
B.granulata	0.6611 p=.019	0.4731 p=.120	0.3332 p=.290	-0.6631 p=.019	0.4023 p=.195	-0.6196 p=.032	0.7327 p=.007	0.4854 p=.110
B.spinosa	0.7575 p=.004	0.4302 p=.163	0.3604 p=.250	-0.7307 p=.007	0.4673 p=.126	-0.661 p=.019	0.6927 p=.013	0.6423 p=.024
B.tuberculata	0.8335 p=.001	0.5604 p=.058	0.4563 p=.136	-0.733 p=.007	0.385 p=.217	-0.6915 p=.013	0.8376 p=.001	0.6732 p=.016
C.cingulata	0.7411 p=.006	0.3976 p=.201	0.4119 p=.183	-0.5795 p=.048	0.2173 p=.498	-0.5564 p=.060	0.6149 p=.033	0.4621 p=.130
C.madrasensis	0.0223 p=.945	-0.1571 p=.626	0.1331 p=.680	0.0034 p=.992	-0.22 p=.492	-0.0669 p=.836	-0.1347 p=.676	-0.0929 p=.774
C.obtusa	0.7343 p=.007	0.4173 p=.177	0.3971 p=.201	-0.6418 p=.024	0.3712 p=.235	-0.5811 p=.048	0.5713 p=.052	0.5483 p=.065
H.conoidalis	0.5676 p=.054	0.3679 p=.239	0.4492 p=.143	-0.5967 p=.041	0.2371 p=.458	-0.557 p=.060	0.5704 p=.053	0.5035 p=.095
L.melanostoma	0.9642 p=.000	0.7728 p=.003	0.3447 p=.272	-0.7305 p=.007	0.6525 p=.021	-0.6455 p=.023	0.892 p=.000	0.6592 p=.020
L.scabra	0.937 p=.000	0.6947 p=.012	0.325 p=.303	-0.6742 p=.016	0.565 p=.056	-0.5064 p=.093	0.8401 p=.001	0.5414 p=.069
M.meretrix	0.5463 p=.066	0.3398 p=.280	0.3297 p=.295	-0.4619 p=.131	0.0107 p=.974	-0.4993 p=.098	0.588 p=.044	0.367 p=.241
M.ovum	0.6636 p=.019	0.4436 p=.149	0.3496 p=.265	-0.5277 p=.078	0.0723 p=.823	-0.5634 p=.056	0.6999 p=.011	0.4439 p=.148
N.violacea	0.2835 p=.372	0.1034 p=.749	-0.0122 p=.970	-0.2358 p=.461	-0.1399 p=.665	-0.2667 p=.402	0.4738 p=.120	0.1787 p=.578
O.gibbosa	0.8493 p=.000	0.7093 p=.010	0.4596 p=.133	-0.8015 p=.002	0.7335 p=.007	-0.6847 p=.014	0.8488 p=.000	0.8284 p=.001
R.bulbosa	0.5081 p=.092	0.0446 p=.891	-0.0169 p=.958	-0.1771 p=.582	-0.2277 p=.477	-0.319 p=.312	0.414 p=.181	0.1406 p=.663
T.atenuata	0.1759 p=.584	0.2585 p=.417	0.0806 p=.803	-0.5076 p=.092	0.2617 p=.411	-0.4861 p=.109	0.2847 p=.370	0.3654 p=.243
T.duplicata	0.6704 p=.017	0.5068 p=.093	0.5684 p=.054	-0.7322 p=.007	0.625 p=.030	-0.6214 p=.031	0.4723 p=.121	0.5991 p=.040
T.telescopium	0.261 p=.413	0.055 p=.865	-0.1286 p=.690	-0.1291 p=.689	-0.2167 p=.499	-0.252 p=.429	0.4161 p=.178	0.0553 p=.864

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 99. Simple correlation data between physico-chemical parameters and molluscs of site II

	AT	SST	DWT	DO	FCO^2	Phos	pH	Sal
				2004-05				
B.spinosa	0.6204 p=.031	0.7398 p=.006	0.0579 p=.858	-0.1782 p=.580	-0.0388 p=.905	-0.3033 p=.338	0.5178 p=.085	0.1845 p=.566
C.madrasensis	0.2225 p=.487	0.382 p=.220	-0.2618 p=.411	0.2866 p=.367	-0.3189 p=.312	-0.0076 p=.981	0.3677 p=.240	0.0165 p=.959
L.scabra	0.3122 p=.323	0.5894 p=.044	-0.1061 p=.743	0.1093 p=.735	-0.29 p=.361	-0.2151 p=.502	0.4741 p=.119	0.3255 p=.302
M.meretrix	0.4565 p=.136	0.6882 p=.013	0.1114 p=.730	-0.4037 p=.193	0.1526 p=.636	-0.5416 p=.069	0.5641 p=.056	0.6207 p=.031
N.violacea	0.6389 p=.025	0.6784 p=.015	0.1604 p=.618	-0.2152 p=.502	0.0633 p=.845	-0.2595 p=.415	0.2266 p=.479	0.3383 p=.282
O.gibbosa	0.5625 p=.057	0.672 p=.017	-0.1193 p=.712	-0.0831 p=.797	0.0479 p=.883	-0.153 p=.635	0.3856 p=.216	0.1307 p=.686
P.globosa	-0.6613 p=.019	-0.5556 p=.061	-0.311 p=.325	0.7288 p=.007	-0.4143 p=.181	0.6283 p=.029	-0.7975 p=.002	-0.3144 p=.320
R.bulbosa	0.1954 p=.543	0.2485 p=.436	0.1642 p=.610	-0.2279 p=.476	0.081 p=.802	-0.4719 p=.121	0.2447 p=.443	0.5182 p=.084
T.telescopium	0.5956 p=.041	0.7636 p=.004	0.208 p=.517	-0.3927 p=.207	0.1425 p=.659	-0.4622 p=.130	0.4648 p=.128	0.4738 p=.120
				2005-06				
B.spinosa	0.6831 p=.014	0.6475 p=.023	0.7025 p=.011	-0.7717 p=.003	0.2997 p=.344	-0.6494 p=.022	0.6384 p=.025	0.3252 p=.302
C.madrasensis	0.6307 p=.028	0.4012 p=.196	0.3989 p=.199	-0.4253 p=.168	0.3597 p=.251	-0.5578 p=.060	-0.002 p=.995	0.6584 p=.020
L.scabra	0.5373 p=.072	0.2697 p=.397	0.2493 p=.435	-0.3025 p=.339	0.0213 p=.948	-0.2351 p=.462	0.1288 p=.690	0.1447 p=.654
M.meretrix	0.6426 p=.024	0.4429 p=.149	0.3516 p=.262	-0.45 p=.142	0.033 p=.919	-0.5034 p=.095	0.1186 p=.713	0.2159 p=.500
N.violacea	0.7445 p=.005	0.6459 p=.023	0.6993 p=.011	-0.804 p=.002	0.3859 p=.215	-0.7291 p=.007	0.4196 p=.175	0.3645 p=.244
O.gibbosa	0.7123 p=.009	0.7802 p=.003	0.7789 p=.003	-0.6906 p=.013	0.4471 p=.145	-0.575 p=.050	0.4872 p=.108	0.5316 p=.075
P.globosa	-0.7425 p=.006	-0.7308 p=.007	-0.6296 p=.028	0.784 p=.003	-0.512 p=.089	0.5213 p=.082	-0.6242 p=.030	-0.3085 p=.329
R.bulbosa	0.6129 p=.034	0.3282 p=.298	0.1166 p=.718	-0.2503 p=.433	-0.11 p=.734	-0.3034 p=.338	0.2927 p=.356	0.1406 p=.663
T.telescopium	0.7122 p=.009	0.5735 p=.051	0.5646 p=.056	-0.6303 p=.028	0.3289 p=.297	-0.5908 p=.043	0.2651 p=.405	0.6155 p=.033

Marked correlations are significant at $p < .05000$
N=12 (Case wise deletion of missing data)

Table: 100. Simple correlation data between physico-chemical parameters and molluscs of site III

	AT	SST	DWT	DO	FCO²	Phos	pH	Sal
2004-05								
L.melanostoma	0.6283 p=.029	0.6579 p=.020	0.1791 p=.578	-0.2378 p=.457	0.1843 p=.566	-0.4975 p=.100	0.5359 p=.073	0.2423 p=.448
L.scabra	0.7187 p=.008	0.6094 p=.035	0.3409 p=.278	-0.343 p=.275	0.2307 p=.471	-0.5477 p=.065	0.2931 p=.355	0.2952 p=.352
M.meretrix	0.1049 p=.746	0.5909 p=.043	-0.0597 p=.854	0.0594 p=.855	-0.1586 p=.622	0.234 p=.464	0.3899 p=.210	0.1637 p=.611
N.violacea	0.469 p=.124	0.415 p=.180	-0.087 p=.788	0.1145 p=.723	-0.037 p=.909	-0.4204 p=.174	0.6456 p=.023	0.0444 p=.891
T.brenneus	0.1202 p=.710	0.6449 p=.024	0.1931 p=.548	0.0905 p=.780	-0.3417 p=.277	0.0179 p=.956	0.0532 p=.870	0.5877 p=.044
2005-06								
L.melanostoma	0.7258 p=.008	0.4182 p=.176	0.5047 p=.094	-0.5233 p=.081	0.026 p=.936	-0.6301 p=.028	0.1359 p=.674	0.4582 p=.134
L.scabra	0.6413 p=.025	0.3135 p=.321	0.3036 p=.337	-0.4069 p=.189	-0.0337 p=.917	-0.5597 p=.058	0.1441 p=.655	0.2825 p=.374
M.meretrix	0.3898 p=.210	0.013 p=.968	0.1244 p=.700	-0.2014 p=.530	-0.1775 p=.581	-0.1624 p=.614	0.2785 p=.381	0.2035 p=.526
M.ovum	0.0539 p=.868	0.0613 p=.850	0.1888 p=.557	-0.0523 p=.872	-0.2432 p=.446	-0.164 p=.611	0.2343 p=.464	0.2392 p=.454
N.violacea	0.0432 p=.894	-0.2777 p=.382	-0.173 p=.591	0.2015 p=.530	-0.6053 p=.037	-0.0735 p=.820	0.0733 p=.821	-0.0194 p=.952
P.globosa	-0.7866 p=.002	-0.8509 p=.000	-0.8534 p=.000	0.8119 p=.001	-0.5479 p=.065	0.5724 p=.052	0.1288 p=.690	-0.6898 p=.013
T.brenneus	0.2845 p=.370	-0.0012 p=.997	0.018 p=.956	-0.2063 p=.520	-0.0402 p=.901	-0.144 p=.655	0.2502 p=.433	-0.0184 p=.955

Marked correlations are significant at p < .05000
N=12 (Case wise deletion of missing data)

Table: 9

ZOOPLANKTONS

No.	Species	Sites		
		I	II	III
PHYLUM : ARTHOPODA				
ORDER: CALANOIDA				
Family : Acartiidae				
1.	*Acartia erythrae*	+	-	-
2.	*Acartia gracillis*	+	+	+
3.	*Acartia major*	+	+	+
ORDER : SESSILIA				
Family : Balanidae				
4.	*Balanus amphitrite*	+	-	-
5.	*Balanus tintinnabulum*	+	-	-
Family :Paracalanidae				
6.	*Acrocalanus gibber*	+	-	-
7.	*Paracalanus parvus*	+	+	+
Family : Diaptomidae				
8.	*Diaptomus parvus*	+	+	+
Family : Pseudodiaptomidae				
9.	*Pseudodiaptomus aurivelli*	+	+	+
Family : Calanidae				
10.	*Canthocalanus pauper*	+	+	+
ORDER : CYCLOPOIDA				
Family : Cyclopodidae				
11.	*Cyclops scutifer*	+	+	+
12.	*Cyclops virdis*	+	-	-
13.	*Mesocyclops hyalinus*	+	+	-
14.	*Mesocyclops leuckarti*	+	+	+
15.	*Eucyclops agillis*	+	-	-
Family : Oithonidae				
16.	*Oithona bravicornis*	+	+	+
17.	*Oithona rigida*	+	+	+
18.	*Oithona similis*	+	-	-
ORDER : HARPACTICOIDA				
Family : Euterpinidae				
19.	*Eutrepina alcifrons*	+	+	+
ORDER: ISOPODA				
Family : Cirolanidae				
20.	*Cirolana fluviatilis*	+	-	+
ORDER: CLADOCERA				
Family : Daphniidae				
21.	*Daphnia* species	+	-	+
22.	*Illyocryptus spinifer*	-	-	+
Family : Ostracoda				
23.	*Ostracoda* species	+	-	-
ORDER : DECAPODA				
Family : Penaeidae				
24.	Juveniles of *Metapenaeus dobsoni*	+	+	+

25.	Juveniles of *Metapenaeus monocerous*	+	+	+
26.	Juveniles of *Penaeus indicus*	+	+	+
Family : Luciferidae				
27.	*Lucifer hanseni*	+	+	+
Family : Diogenidae				
28.	*Clibanarius padavensis*	+	-	-
Family : Sesarmidae				
29.	*Sesarma lanatum*	+	+	+
Family: Portunidae				
30.	*Scylla serrata*	+	+	-
31.	*Thalamita crenata*	-	+	+
ORDER : VENEROIDAE				
Family : Veneridae				
32.	*Meretrix meretrix*	+	+	+
33.	*Paphia malabarica*	+	-	-
ORDER : DIPLOSTRACA				
Family : Sididae				
34.	*Diaphanosoma sarsi*	+	-	-
35.	*Penilia avirostris*	+	+	-
ORDER : MYTILOIDA				
Family : Mytilidae				
36.	*Perna virdis*	+	-	-
ORDER : MYSIDA				
Family : Mysidae				
37.	*Mesopodopsis orientallis*	+	+	+
ORDER : TANAIDACEA				
Family : Tanaidae				
38.	*Tanais philetaerus*	+	+	+
ORDER : MESOGASTROPODA				
Family : Potamididae				
39.	*Telescopium telescopium*	+	+	+
40.	*Cerithidea obtusa*	+	-	-
PHYLUM : CHAETOGNATHA				
Family : Sagittidae				
41.	*Sagitta bedoti*	+	-	+
42.	*Sagitta enflatta*	+	+	+

[+ = Present, - = absent]

Table: 10
PRAWNS

No.	Species	Sites		
		I	II	III
ORDER : DECAPODA				
Family : PENAEIDAE				
1	*Penaeus indicus*	+	+	+
2	*Penaeus monodon*	+	-	+
3	*Metapenaeus monocerous*	+	+	+
4	*Metapenaeus dobsoni*	+	-	+
Family : HIPPOLYTIDAE				
5	*Macrobrachium rosenbergii*	+	-	+

Table: 11
CRABS

No.	Species	Sites		
		I	II	III
ORDER : DECAPODA				
Family : PORTUNIDAE				
1	*Charabydis feriatus*	+	-	-
2	*Charabydis lucifera*	+	+	+
3	*Portunus pelagicus*	-	-	+
4	*Scylla granulate*	+	-	-
5	*Scylla serrata*	+	-	+
6	*Thalamita crenata*	+	-	-
Family : OCYPODIDAE				
7	*Dotilla intermedia*	+	-	-
8	*Dotilla myctiroides*	+	+	+
9	*Gelasimus annulipes*	+	-	-
10	*Ocypode sp.*	+	-	-
11	*Uca acuta acuta*	+	-	+
12	*Uca annulipes*	+	-	-
13	*Uca lactea*	+	+	+
Family : GRAPSIDAE				
14	*Metapogrsapus messor*	+	-	-
15	*Sesarma lanatum*	+	-	-
16	*Sesarma taeniolata*	+	+	-
17	*Sesarma granulata*	+	-	-

[+ = Present, - = absent]

Table: 12
MOLLUSCS

No.	Species	Sites		
		I	II	III
Family : Arcidae				
1	*Anadara granosa*	+	-	-
2	*Bulbo granulata*	+	-	-
3	*Bulbo spinosa*	+	+	-
4	*Bulbo tuberculata*	+	-	-
5	*Calypraea extinctorium*	+	-	-
Family : Cardidae				
6	*Cardium asiaticum*	+	-	-
7	*Cardium flavum*	+	-	-
Family : Volemidae				
8	*Cellana radiata*	+	-	-
Family : Potamidae				
9	*Cerithidea cingulata*	+	-	-
10	*Cerithidea obtusa*	+	-	-
11	*Telescopium telescopium*	+	+	-
Family : Ostreidae				
12	*Crassotrea madrasensis*	+	+	-
Family : Harpidae				
13	*Harpa conoidalis*	+	-	-
Family : Littorinidae				
14	*Littorina melanostoma*	+	-	+
15	*Littorina scabra*	+	+	+
Family : Mactridae				
16	*Mactra violacea*	+	-	-
Family : Veneridae				
17	*Meretrix meretrix*	+	+	+
18	*Meretrix ovum*	+	-	-
19	*Paphia malabarica*	+	-	-
20	*Paphia textile*	+	-	-
21	*Murex tribulus*	+	-	+
Family : Naticidae				
22	*Natica vitellus*	+	-	-
Family : Neritidae				
23	*Dostia violacea*	+	+	+
24	*Neritina smithi*	+	-	-
25	*Neritina violacea*	+	+	+
26	*Oliva carneola*	+	-	-
27	*Oliva gibbosa*	+	+	-
Family : Mytilidae				
28	*Perna virdis*	+	-	-
Family : Pilidae				
29	*Pila globosa*	-	+	+
30	*Rapona bulbosa*	+	+	-
Family : Strombidae				
31	*Tibia curta*	+	-	-
Family : Turbinidae				
32	*Turbo brenneus*	+	-	+
Family : Turritellidae				
33	*Turitella atenuata*	+	-	-
34	*Turitella duplicata*	+	-	-

[+ = Present, - = absent]

Table: 13
FISHES

No.	Species	Sites		
		I	II	III
Family : Gobiidae				
1	*Acentrogobius audax*	+	-	-
2	*Glossobius biocellatus*	+	+	+
3	*Glossobius giurus*	+	+	-
4	*Gobidae*	-	+	+
5	*Oxyurichthys formosciere*	+	-	-
6	*Oxycurichthys tentacularia*	+	-	-
Family : Cyprinidae				
7	*Puntius dorsalis*	+	+	+
8	*Puntius filamentosus*	+	+	+
9	*Puntius nigrofasciatus*	+	+	+
10	*Puntius sarana subnasutus*	+	-	-
Family : Ambassidae				
12	*Ambassis ambassis*	+	+	+
13	*Ambassis dayii*	+	+	+
14	*Ambassis gymnocephalus*	+	-	+
Family : Apogonidae				
15	*Apogon sp.*	-	-	+
16	*Apotallus loci*	+	-	-
Family : Carangidae				
17	*Carangoides malabaricus*	+	-	+
18	*Carangoides praeustis*	+	-	+
19	*Carangus bloch*	+	+	+
	Alepes kleinii	+	-	+
20	*Carapon jupa*	+	-	-
Family : Chanidae				
21	*Chanos chanos*	+	+	+
Family : Cynoglossidae				
22	*Cynoglossus cynoglossus*	-	+	+
23	*Cynoglossus johnii*	+	-	-
24	*Cynoglossus latineri*	+	+	+
25	*Cynoglossus macrolepidotus*	+	-	+
26	*Cynoglossus macrostomus*	-	+	+
Family : Eleotridae				
27	*Eleotroides muralis*	+	-	-
Family : Serranidae				
28	*Epinaphales ovina*	+	-	-
29	*Epinasalar malabaricus*	+	-	-
Family : Cichlidae				
30	*Etroplus maculates*	+	+	+
31	*Etroplus suratensis*	+	+	+
Family : Soleidae				
32	*Euryglossa latineri*	+	-	-
Family : Gerridae				
33	*Gerres filamentosus*	+	+	+
34	*Gerres lucidus*	+	+	+
35	*Goniolosa magning*	+	-	-
Family : Lactaridae				

36	*Lactarius lactarius*	+	+	+
Family : Leiognathidae				
37	*Leiognathus blochi*	-	+	-
38	*Leiognathus decorus*	-	-	+
39	*Leiognathus equulus*	+	+	+
40	*Leiognathus indicus*	+	+	-
41	*Secutor insidator*	+	-	+
Family : Mugilidae				
42	*Liza parsia*	+	-	+
43	*Liza subverdis*	+	+	+
44	*Liza tade*	-	+	-
45	*Mugil cephalus*	+	-	+
Family : Lutjanidae				
46	*Lutjanus argentimaculatus*	+	+	+
47	*Lutjanus fulviflanes*	+	-	-
48	*Lutjanus johnii*	+	-	+
Family : Mullidae				
49	*Mulloidichthys flavolineatus*	+	+	-
50	*Myster butro*	+	-	+
Family : Bagridae				
51	*Mystus gulio*	-	-	+
Family : Platycephalidae				
52	*Platycephalus indicus*	+	-	-
53	*Pseudoroninus euparius*	+	-	-
Family : Hemiramphidae				
54	*Hemiramphus* species			
55	*Zenarchopterus striga*	-	+	-
Family : Synodontidae				
56	*Saurida tumbil*	+	-	+
Family : Scatophagidae				
57	*Scatophagus argus*	+	+	+
Family : Sillaginidae				
58	*Sillago sihama*	+	-	-
Family : Sphyraenidae				
59	*Barracuda sp.*	+	+	+
60	*Sphyraena barracuda*	-	-	+
Family : Engraulidae				
61	*Stolephorus sp.*	+	+	+
62	*Thryssa mystax*	-	-	+
Family : Synanceiidae				
63	*Stone fish* (un identified)	-	-	-
Family : Tetraodontidae				
64	*Tetradon travancoricus*	+	-	+
Family : Teraponidae				
65	*Therapon jarbua*	+	-	+

[+ = Present, - = absent]

Table: 14
INSECTS

No	Species	Sites I	II	III
ORDER : ORTHOPTERA				
Family : ACRIDIDAE				
1	*Acrida exaltata*	+	-	+
2	*Hieroglyphus banian*	-	-	+
3	*Hieroglyphus farcifer*	+	-	+
4	*Oxya fuscovittala*	+	-	+
5	*Oxya hyla hyla*	-	-	+
Family : CARABIDAE				
6	*Brachynus species*	+	-	+
Family : CERAMBYCIDAE				
7	*Batocera rufomaculata*	+	-	+
8	*Ceresim flavipes*	+	-	+
9	*Plocaederus* species	+	+	+
ORDER : HEMIPTERA				
Family : Diaspididae				
11	*Aspidotus destructor*	-	-	+
Family : Pentatomidae				
12	*Nezara viridula*	+	+	+
13	*Chrysocoris* (species1)	+	+	+
14	*Chrysocoris* (species2)	+	+	+
Family : EULOPHIDAE				
15	*Aprostoctus* species	+	-	-
Family : FULGORIDAE				
16	*Dysdercus cingulatus*	-	-	+
Family : GRYLLIDAE				
17	*Gryllus assiminis*	+	-	-
ORDER : COLEOPTERA				
Family : Chrysomelidae				
18	*Altica species*	+	+	+
19	*Aspidomorpha furcata*	+	+	+
20	*Aspidomorpha fuscopunctata*	+	+	+
21	*Aulacophora lewesi*	+	+	+
22	*Aulacophora foveicollis*	+	+	+
23	*Aulacophora stevensi*	+	+	+
24	*Cassida circumdata*	+	+	+
25	*Cassida* species	+	+	+
26	*Chiridopsis bipunctata*	+	+	+
27	*Chiridopsis undecimnotata*	+	+	+
28	*Colaposoma* species	+	+	+
29	*Cryptocephalus* species	+	+	+
30	*Laccoptera quaturodeciminotata*	+	+	+
31	*Lema* species 1	+	+	+
32	*Lema* species 2	+	+	+
33	*Lema* species 3	+	+	+
34	*Monolepta bifasciata*	+	+	+
35	*Philopona vibex*	+	-	-
36	*Sagra* species	+	+	+

37	*Sphaeroderma* species	+	+	+
38	*Tricliona* species 1	+	+	+
39	*Tricliona* species 2	+	-	+
40	*Pseudocophora* species	+	-	-
Family : Curculionidae				
41	*Myllocerus viridanus*	+	+	+
42	*Sitophilus* species	+	+	+
43	*Sitophilus conicollis*	+	+	+
Family : ANTHICIDAE				
44	*Anthicus* species 1	+	-	-
45	*Anthicus* species 2	+	-	-
Family : CERAMBYCIDAE				
46	*Batocera rufomaculata*	+	+	+
47	*Ceresium flavipes*	+	+	+
48	*Plocaederus* species	+	-	+
49	*Sthenias grisator*	+	-	-
50	*Olenecamptus genus*	+	+	+
Family : Dytiscidae				
51	Larvae of *Dytiscidae*	+	+	+
ORDER : ODONATA				
Family : Coenagrionidae				
52	*Aciagrion occidentale*	+	+	+
53	*Agriocnemis pygmae*	+	+	+
54	*Ceriagrion cerinorubellum*	+	+	+
55	*Ischnura aurora aurora*	+	-	-
56	*Pseudagrion microcephalum*	+	-	-
57	*Aethrimanta brevipennis*	+	-	-
Family : Libellulidae				
58	*Brachythemis contaminat*	+	-	-
59	*Crocothemis servilia servilia*	+	-	-
60	*Diplacodes trivalis*	-	+	+
61	*Macrodiplox cora*	+	+	-
62	*Neurothemis chrysis*	-	+	+
63	*Neurothemis ftulvia*	+	+	+
64	*Orthetrum Sabina*	+	+	+
65	*Pantala flavescens*	+	+	+
66	*Potamarcha congener*	+	+	+
67	*Rhodothemis rufa*	+	+	+
68	*Rhyothemis variegata*	+	+	+
69	*Tholymis tillarga*	+	+	-
70	*Urothemis signata signata*	+	+	-
71	*Zyxomma petiolatum*	+	+	-
72	*Orthetrum luzonicum*	+	-	-
Family : Lestidae				
73	*Lestes elatus*	+	+	+
Family : Calopteryginae				
74	*Vestallis gracillis gracillis*		+	+
Family : Gomphidae				
75	*Ictinogomphus rapax*	+	+	+
76	*Gynacntha dravida*	+	+	
ORDER : NEUROPTERA				
Family :Chrysopidae				
77	Chrysopidae (species 1)	+	+	+
78	*Chrysopea orestes*	+	-	+

ORDER : DIPTERA				
Family : Tephritidae				
79	*Dacus cucurbitae*			
80	*Colletes* species			
Family : Asilidae				
81	*Asilidae species*			
Family : Tabanidae				
82	Tabanid (1 species)	+	-	+
Family : Coccinelidae				
83	*Epilachina* species			
Family : Tipulidae				
84	Tipulidae (1 species)	+	-	+
ORDER : HYMENOPTERA				
Family : Vespidae				
85	*Delta conoidus*	+	-	+
86	*Delta petiolatus*	+	+	+
87	*Vespa affinis*	+	+	+
88	*Vespa tropica*	+	+	+
89	*Ropalida* species	+	+	+
90	*Rhinchium* species			
91	*Propelidae* (genus)	+	-	-
Family : Apidae				
92	*Apis florae*	+	+	+
93	*Apis nomia*	+	-	+
94	*Xylocopa* species	+	+	+
95	*Thyerus* species	+	-	-
96	*Coelioxys* species	+	-	-
97	*Amigilla* species	-	-	+
98	*Colletes* species	+	-	+
Family : Ichneumonidae				
99	*Veerendrania orocistroceri*	+	-	-
100	*Goryphus tirkyii*	+	-	+
101	*Henicospilus unifasciatus*	+	-	-
Family : Formicidae				
102	*Camponotus* (1 species)	+	+	+
103	*Camponotus* (2 species)	+	+	+
104	*Crematogaster* species	+	+	+
105	*Monomorium* species	+	+	+
106	*Monomorium indicum*	+	+	+
107	*Oecophylla smaragdina*	+	+	+
108	*Paratrechina* species	+	-	+
109	*Pheidoel* species	+	-	+
110	*Solenopsis* (1 species)	+	-	+
111	*Solenopsis* (2 species)	+	+	+
112	*Solenopsis geminate*	+	+	+
113	*Velvet ant*	+	-	-
114	*Odontomachus species*	+	-	+
115	*Leptogenys chinensis*	+	+	+
116	*Anoplolepis sp*	+	+	+
117	*Tetramorium rufonigra*	+	-	-
Family : Xylocopidae				
118	*Xylocopalataeille* species	+	+	+
119	*Xylocoris bicolor*	+	+	+
Family : Scelionidae				

120	*Palpotelia kieffer*	+	-	-
Family : Braconidae				
121	*Apanteles* species	-	-	+
122	*Bracon* species	+	+	+
Family : Anthophoridae				
123	Anthophoridae (species -1)	-	-	+
Family : Specidae				
124	*Prionyx* species	+	+	-
125	*Sceliphron javanum*	+	-	+
126	*Chalybion bengalensis*	+	+	+
Family : Scolidae				
127	*Scolia (Discolia)*	+	+	+
128	*Megacampsomeris grossa*	+	+	+
129	*Campsomeris collaris collaris*	+	+	+
130	*Prionyx* species	+	-	+
131	*Propelidae (genus)*	+	+	+
132	*Polystes (genus)*	+	+	+
133	*Parasammophilia* species	+	-	+
Family : Culicidae				
134	*Aedes* species	+	+	+
135	*Anopheles species*	+	+	+
136	*Culex* species1	+	+	+
137	*Culex quinquefasciatus*	+	+	+
138	*Culex sitiens*	+	+	+
Family : Chalcidoidea				
139	*Tetramesa* species			
140	*Chlorion* species	+	-	+
Family : Pompilidae				
141	Pompilidae (1 species)	+	-	+
ORDER : LEPIDOPTERA				
Family :Papilionidae				
142	*Pachliopta aristolochiae*	+	+	+
143	*Pachliopta hector*	+	-	+
144	*Pachliopta polymnester*	+	-	+
145	*Papilio polytes*	+	+	+
Family : Pieridae				
146	*Catopsila pomona*	+	-	-
147	*Catopsila pyranthe*	+	-	-
148	*Eurema hecabe*	+	-	-
Family : Nymphalidae				
149	*Melanitis leda ismmene*	+	+	+
150	*Orsotrioena medus*	+	-	-
151	*Acraea violae*	+	-	+
152	*Neptis hylas*	+	-	-
153	*Euploea core*	+	+	+
154	*Euthalia aconthea*	+	+	+
155	*Ariadne merione*	+	+	+
156	*Junonia almana*	+	-	+
157	*Junonia atlites*	+	+	+
158	*Tirumala limniace*	+	+	-
159	*Danais limnace*	+	+	+
160	*Danaus chrysippus*	+	+	+
Family : Lycaenidae				
161	*Jamides celeno*	+	-	-

Family: Arctidae				
162	*Estigmena acrae*	+	+	+
Family : Hesperidae				
163	*Hasora chromus*	+	+	+
164	*Gangara thyrsis*	+	+	_
165	*Pelopidas mathias*	+	+	+

[+ = Present, - = absent]

Table: 15
BIRDS

No.	Species	Sites		
		I	II	III
ORDER : FALCONIFORMES				
Family : Acciptridae				
1	*Accipiter badius*	+	-	-
2	*Haliastur indus*	+	+	+
3	*Circus aeruginosus*	+	+	-
4	*Haliaeetus leucogaster*	+	-	-
5	*Pandion haliaetus*	+	-	-
6	*Pernis ptilorhyncus*	+	-	-
7	*Milvus migrans*	+	+	+
Family : Phasianidae				
8	*Gallus gallus murghi*	-	+	+
ORDER : CORACIFORMES				
Family : Alcedinidae				
9	*Alcedo atthis*	+	+	+
10	*Halycon pileata*	+	-	-
11	*Halycon smyrnensis*	+	-	+
12	*Ceryle rudis*	+	-	-
Family : Meropidae				
13	*Merops orientallis*	+	-	+
ORDER : GRUIIFORMES				
Family : RALLIDAE				
14	*Amaurornis phoenicurus*	+	-	-
15	*Apus affinis*	+	-	-
16	*Apus melba*	+	-	-
ORDER : CICONIFORMES				
Family: Ardeidae				
17	*Ardea alba*	+	-	-
18	*Ardea cinerea*	+	+	+
19	*Ardeola grayii*	+	+	+
20	*Ardeola striatus*	+	+	+
21	*Bubulcus ibis*	-	+	+
22	*Egretta garzetta*	+	+	+
23	*Egretta gularis*	+	+	+
24	*Egretta intermedia intermedia*	+	+	+
25	*Nycticorax nycticorax nycticorax*	+	-	-
Family : Ciconidae				
26	*Anastomus oscitans*	+	-	-
ORDER : COLUMBIFORMES				

Family : Columbidae				
27	*Columba livia*	-	+	+
ORDER : CUCULIFORMIDAE				
Family : Cuculidae				
28	*Centropus sinensis*	+	+	+
29	*Eudynamys scolopacea*	+	+	+
ORDER : PASSERIFORMES				
Family : Ploceidae				
30	*Passer domesticus*	+	-	-
31	*Petronia xanthocollis*	+	-	-
Family : Hirundinidae				
32	*Hirundo daurica*	+	-	-
33	*Hirundo rustica*	+	-	-
Family : Oriolidae				
34	*Oriolus oriolus*	+	+	+
Family : Dicuridae				
35	*Dicrurus adsimillis*	+	-	+
Family :Artamidae				
36	*Artamus fuscus*	+	+	-
Family : Sturnidae				
37	*Acridotheres tristis*	+	+	+
Family : Corvidae				
38	*Corvus macrorhynchos*	+	-	+
39	*Corvus splendens*	+	+	+
40	*Dendrocitta vagabunda*	+	-	-
Family : Muscicapidae				
41	*Cisticola juncidis*	+	+	-
42	*Copsychus saularis*	+	-	+
43	*Prinia socialis*	+	+	+
44	*Prinia subflava*	+	-	-
45	*Orthotomus sutorius*	+	-	-
Family : Motacillidae				
46	*Anthus rutulus*	+	-	-
47	*Motacilla cinerea*	+	-	-
48	*Motacilla maderaspatensis*	+	-	-
Family : Nectarinidae				
49	*Nectarinia asciatica*	+	-	-
50	*Nectarinia asiatica*	+	-	-
51	*Phalacrocorax carbo*	+	-	-
52	*Phalacrocorax niger*	+	+	+
ORDER : CHARADRIIFORMES				
Family : Charadriidae				
53	*Pluvalis fulva*	+	+	+
54	*Pluvialis squatarola*	+	-	-
55	*Charadrius alexandrinus*	+	+	-
56	*Charadrius dubis jerdoni*	+	+	-
57	*Charadrius leschenaultii*	+	-	-
58	*Charadrius mongolus*	+	+	-
59	*Numenius arquata*	+	+	+
60	*Limosa lapponica*	+	-	-
61	*Limosa limosa*	+	+	-
62	*Tringa hypoleucos*	+	+	-
63	*Tringa nebularia*	+	+	+
64	*Tringa ochropus*	+	-	-

65	*Tringa stagnatilis*	+	-	-
66	*Tringa terek*	+	-	-
67	*Tringa totanus*	+	-	-
68	*Arenaria interpres*	+	-	-
69	*Calidris alba*	+	+	-
70	*Calidris minuta*	+	-	-
71	*Calidris temminckii*	+	-	-
72	*Calidris testacea*	+	-	-
Family : LARIDAE				
72	*Larus argentatus*	+	+	+
73	*Larus brunnicephalus*	+	+	-
74	*Larus ribundus*	+	+	-
75	*Chilidonias hybrida*	+	+	-
76	*Hydroprogne caspia*	+	-	-
77	*Sterna albifrons*	+	+	-
78	*Sterna hirundo*	+	-	-
ORDER : PSITTACIFORMES				
79	*Psittacula cyanocephala*	+	-	-
80	*Psittacula krameri*	+	-	-

[+ = Present, - = absent]

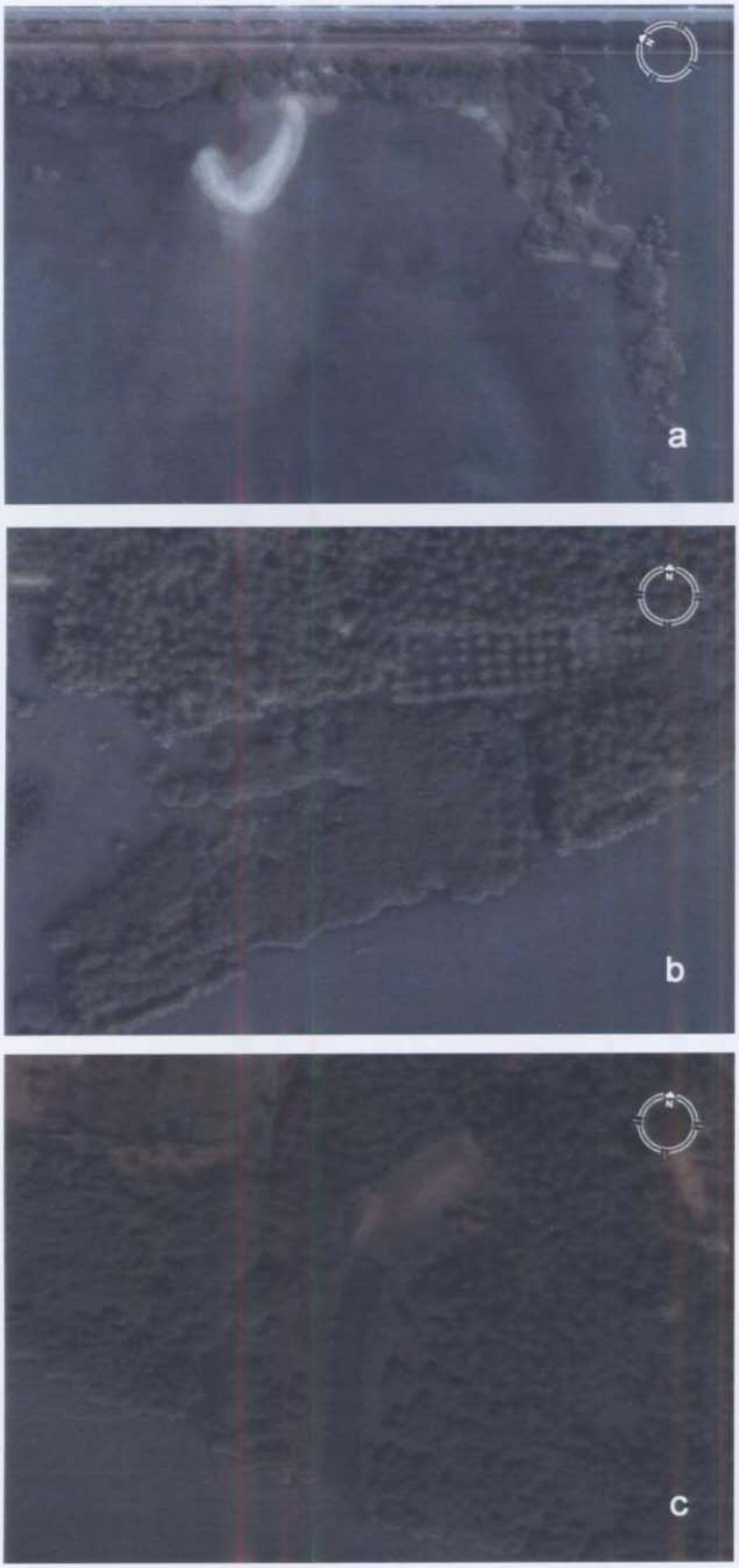
PLATE: 1

a. Kadalundi (site I)

b. Kadalundi (site II)

c. Nalallam (site III)

PLATE 1
STUDY SITES



135 B

PLATE: 2

a. *Sagitta bedoti*

b. *Lucifer hanseni*

c. Larvae of *Thalamita crenata*

d. Larvae of *Scylla serrata*

e. *Mesocyclops leuckarti*

f. *Mesocyclops hyalinus*

g. Larvae of *Penaeus indicus*

h. *Ostracoda* species

i. *Illyocryptus spinifer*

PLATE 2

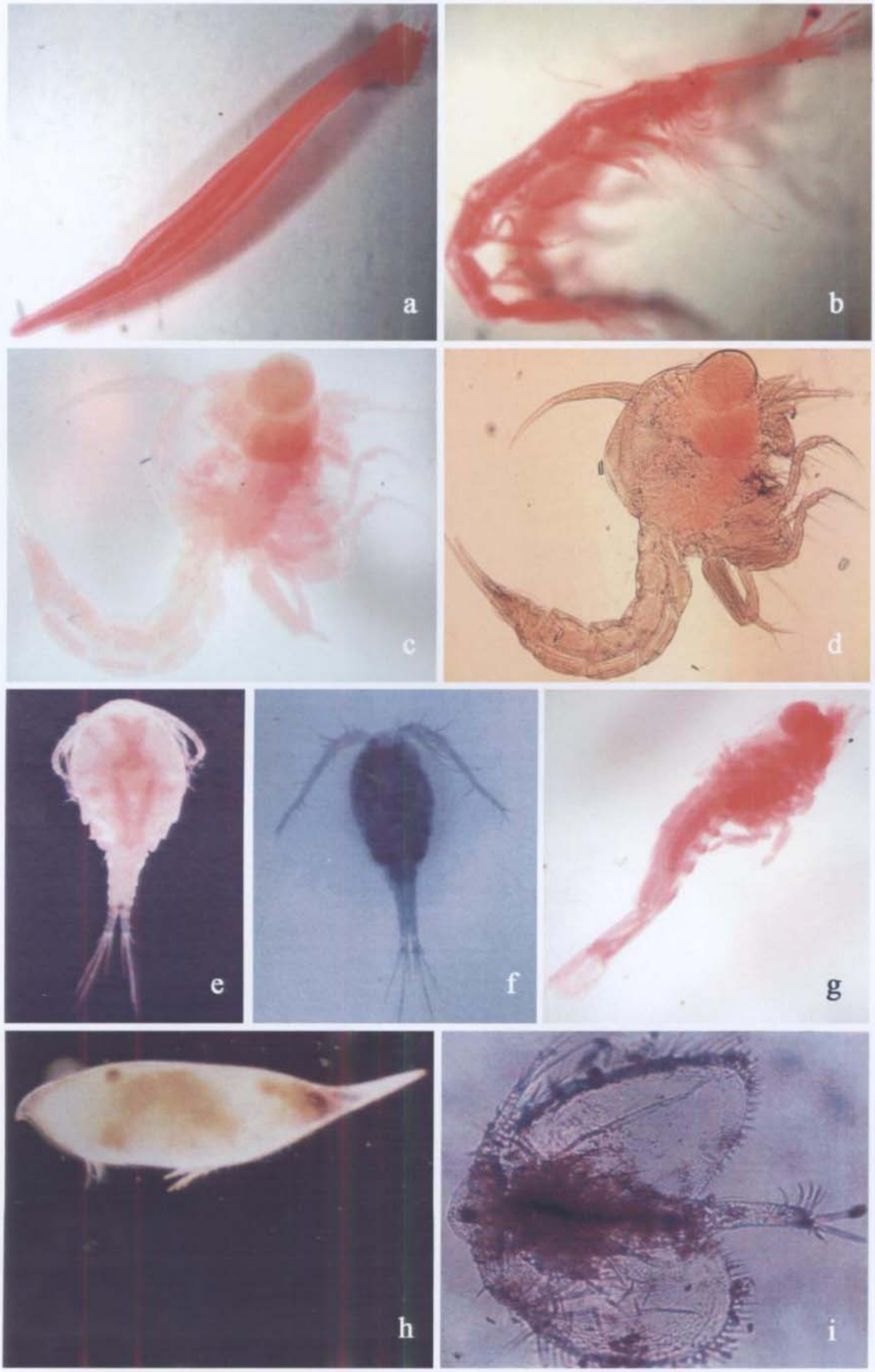


PLATE: 3

a. *Daphnia* species

b. *Canthocalanus pauper*

c. *Acartia gracillis*

d. Larvae of *Sesarma lenatum*

e. *Metapenaeus dobsoni*

f. Cyclops verdis

g. *Eucyclops agillis*

PLATE 3

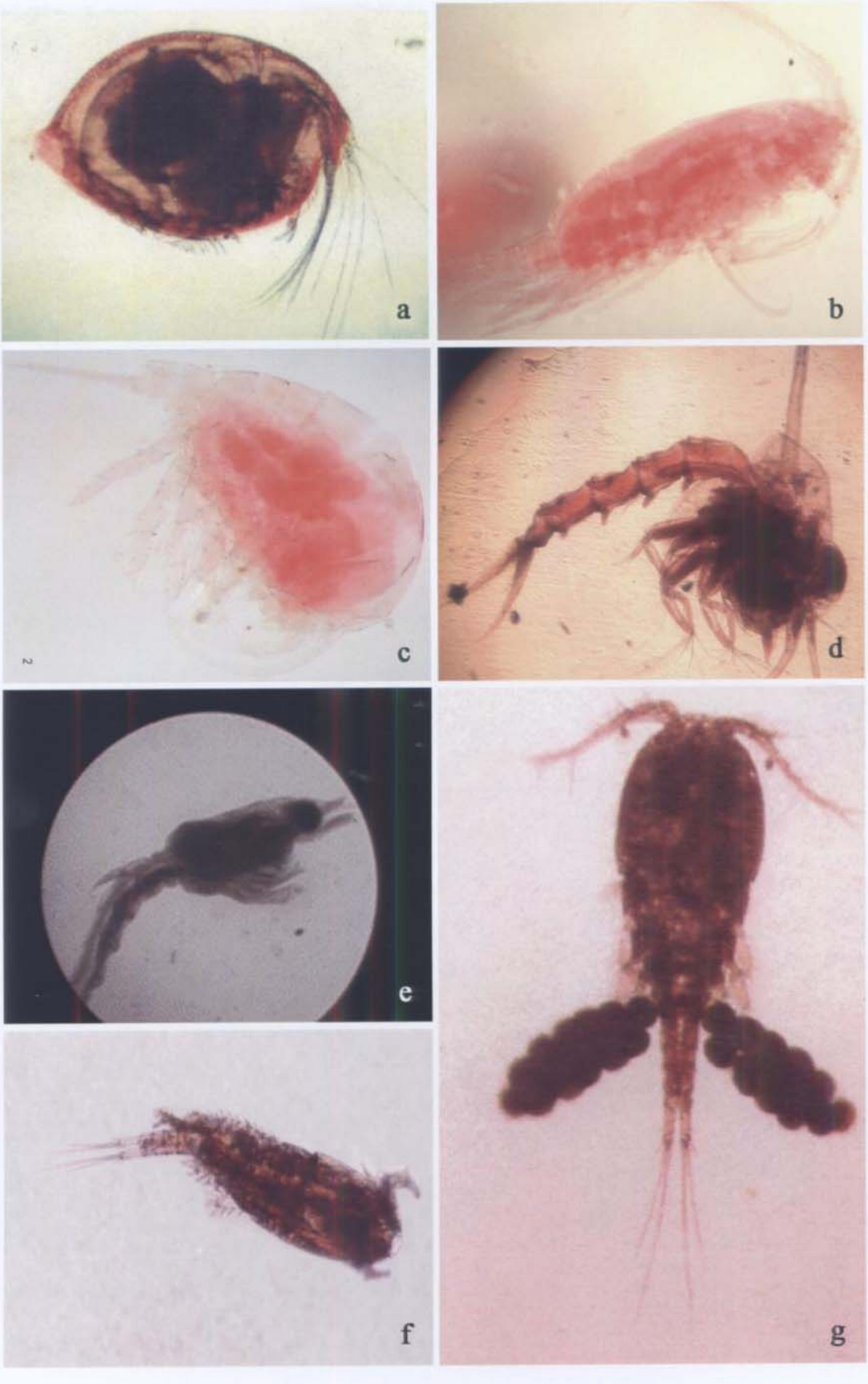


PLATE: 4

a. Uca annulipes

b. Uca lactea

c. Uca acuta

d. Scylla serrata

e. Sesarma taeniolata

f. Portunus pelagicus

g. Metapograspus messor

h. Thalamita crenata

PLATE 4

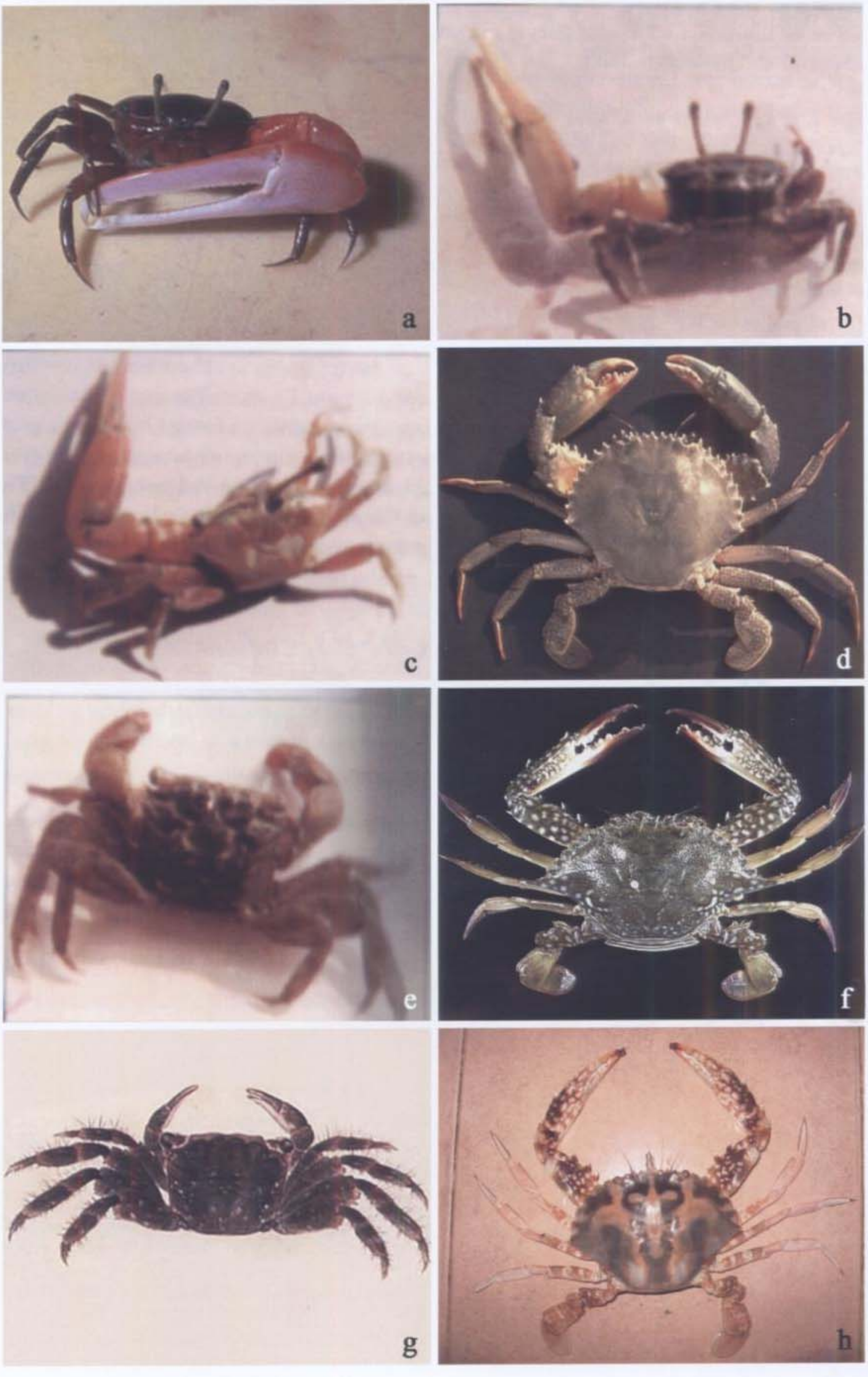


PLATE: 5

a. *Tibia curta*

b. *Rapona bulbosa*

c. *Natica vitellus*

d. *Neritina violacea*

e. *Meretrix sp.*

f. *Paphia malabarica*

g. *Telescopium telescopium*

h. *Oliva sp.*

i. *Neritina sp.*

j. *Meretrix meretrix*

k. *Mactra violacea*

l. *Harpa conoidalis*

26

PLATE 5

135J

PLATE: 6

a. *Turritela duplicata*

b. *Perna virdis*

c. *Oliva gibbosa*

d. *Nertina* species

e. *Crassotrea madrasensis*

f. *Cardium*species

g. *Donax scrotum*

h. *Calyptraea extinctorium*

i. *Cardium flavum*

j. *Cerithidea cingulata*

PLATE 6

135 L

PLATE: 7

a. Metapenaeus dobsoni

b. Penaeus monodon

135M

PLATE 7

135 N

PLATE: 8

a. *Chiridopsis bipunctata*

b. *Chiridopsis undeciminata*

c. *Aulacophora lewesi*

d. *Lema species-1*

e. *Aulacophora foveicollis*

f. *Laccopteraquaturodeciminata*

g. *Philopona vibex*

h. *Aspidomorpha fuscopunctata*

i. *Myllocerus viridanus*

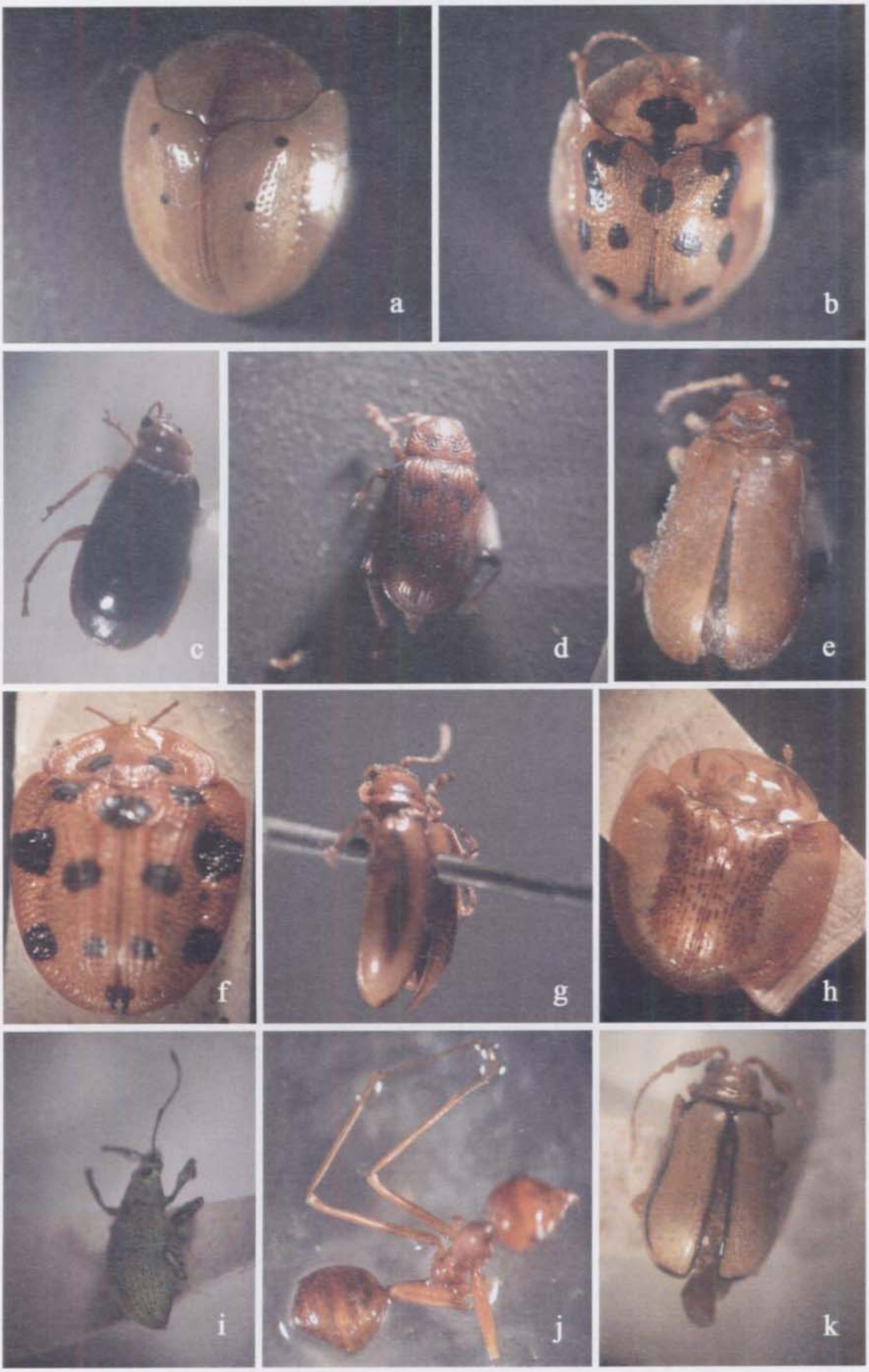
j. *Oecophylla smaragdina*

k. *Aulacophora Stewensi*

1350

32

PLATE 8



135 P

PLATE: 9

a. *Amigilla* species

b. *Rhinchium* species

c. *Propelidae*

d. *Olenecamptus genus*

e. *Chrysocoris* species

f. *Pompilidae*

g. *Asilidae species*

h. *Oxya fuscovittala*

i. *Sceliphron javanum*

j. *Vespa tropica*

k. *Acrida exaltata*

l. *Colletes* species

PLATE 9

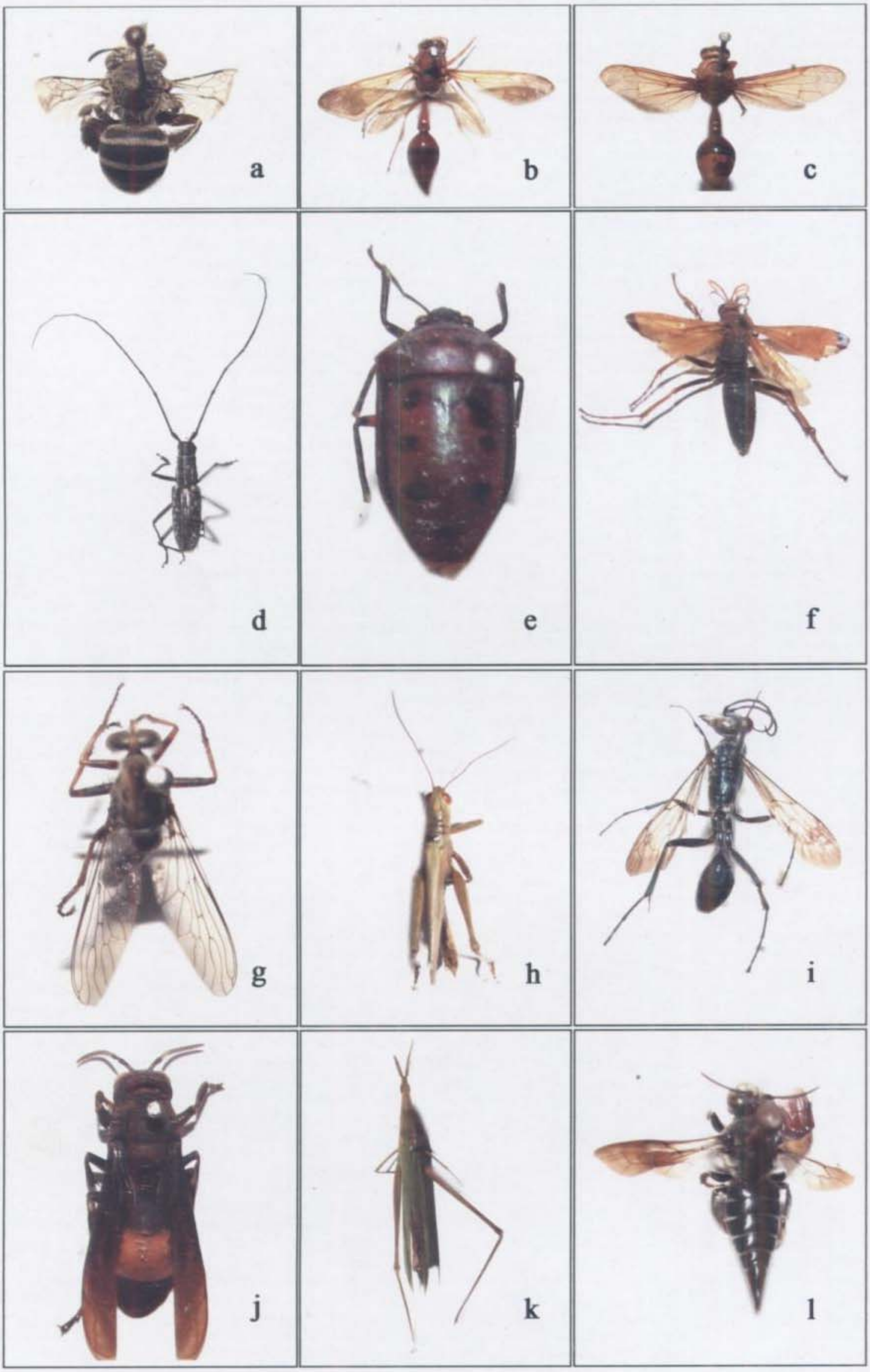


PLATE: 10

a. Propelidae genus

b. Parapsammophilia

c. Delta conoidalis

d. *Rhynchium* species

e. *Vespa aphinis*

f. Chrysomelidae

g. *Xylocopa* species

h. *Thyreus* species

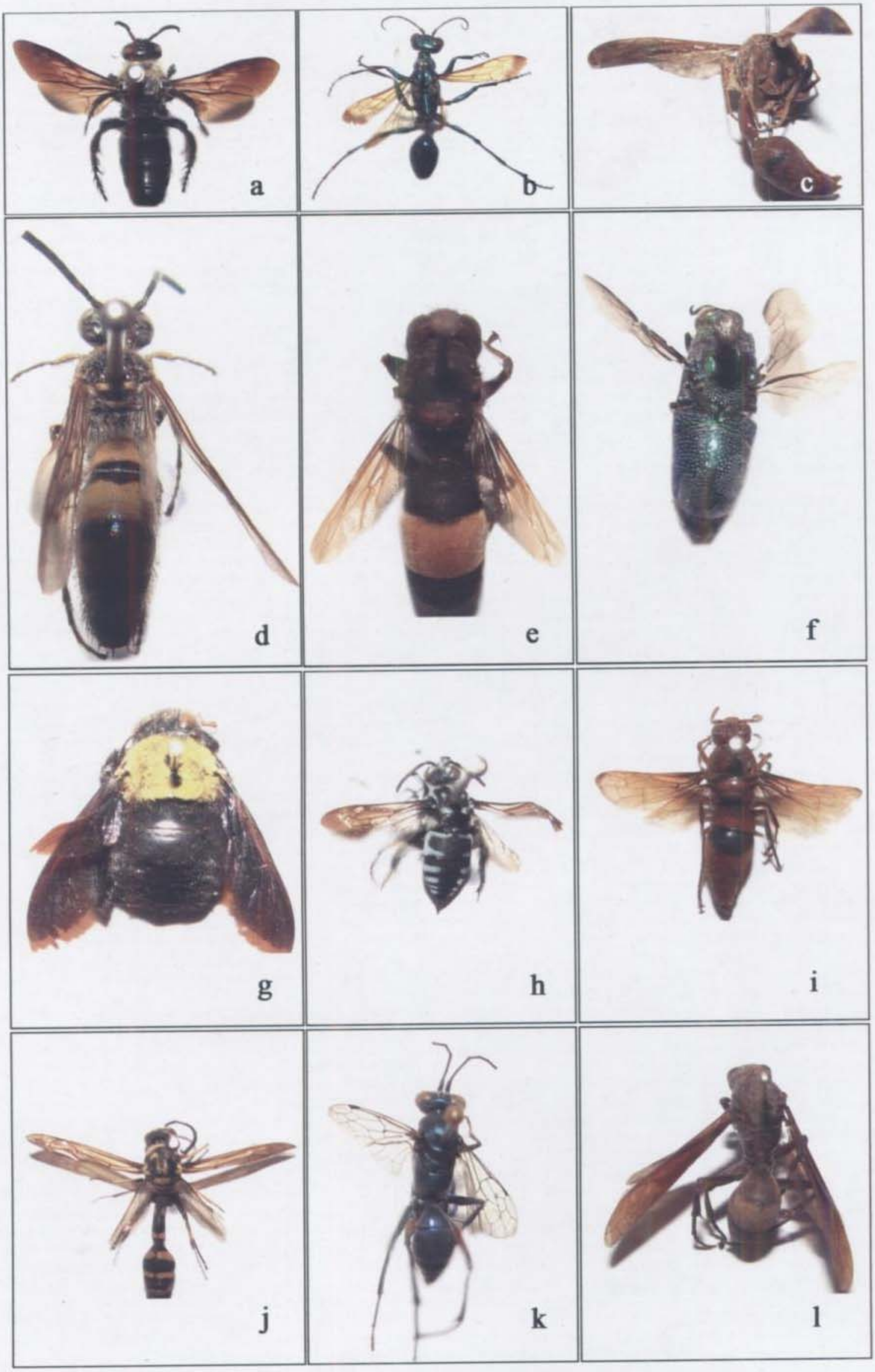
i. Polystes

j. *Delta* species

k. Chalybion bengalensis

l. Pironyx species

PLATE 10



135 T

PLATE: 11

a. *Lema* species -2

b. *Tricliona* species

c. *Cryptocephalus* species

d. *Batocera rufomaculata*

e. *Vespa tropica*

f. *Ceresium longicorne*

g. *Ceresium flavipes*

h. *Dicladispa armigera*

i. *Camsomeriella collaris collaris*

j. *Delta petiolatus*

k. *Henicospilus unifasciatus*

PLATE 11

PLATE: 12

a. *Vestalis gracilis gracilis*

b. *Pachliopta hector*

c. *Sthenias grisator*

d. *Ceresium flavipes*

e. *Gryllus assiminis*

f. *Orsotrioena medus*

g. *Pachliopta polymnester*

h. *Melanitis leda ismmene*

i. *Papilio polytes*

135 W

PLATE 12

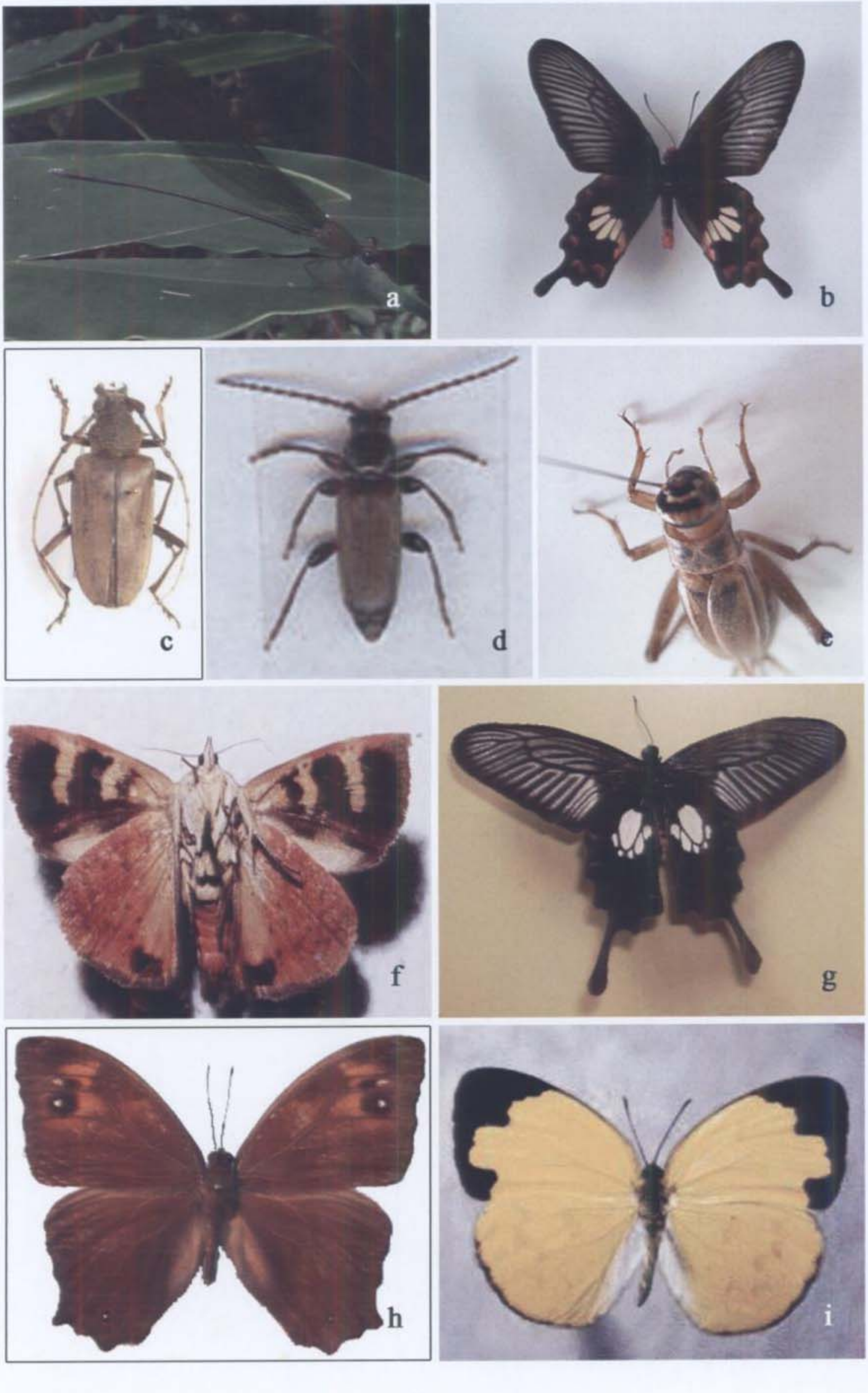


PLATE: 13

a. Neurothemis fulvia

b. Ictinogomphus rapax

c. *Crematogaster* species

d. Vestalis gracilis

e. Crocothemis servilia

f. *Aedes* species

g. *Culex* species1

h. *Apanteles* species

PLATE 13

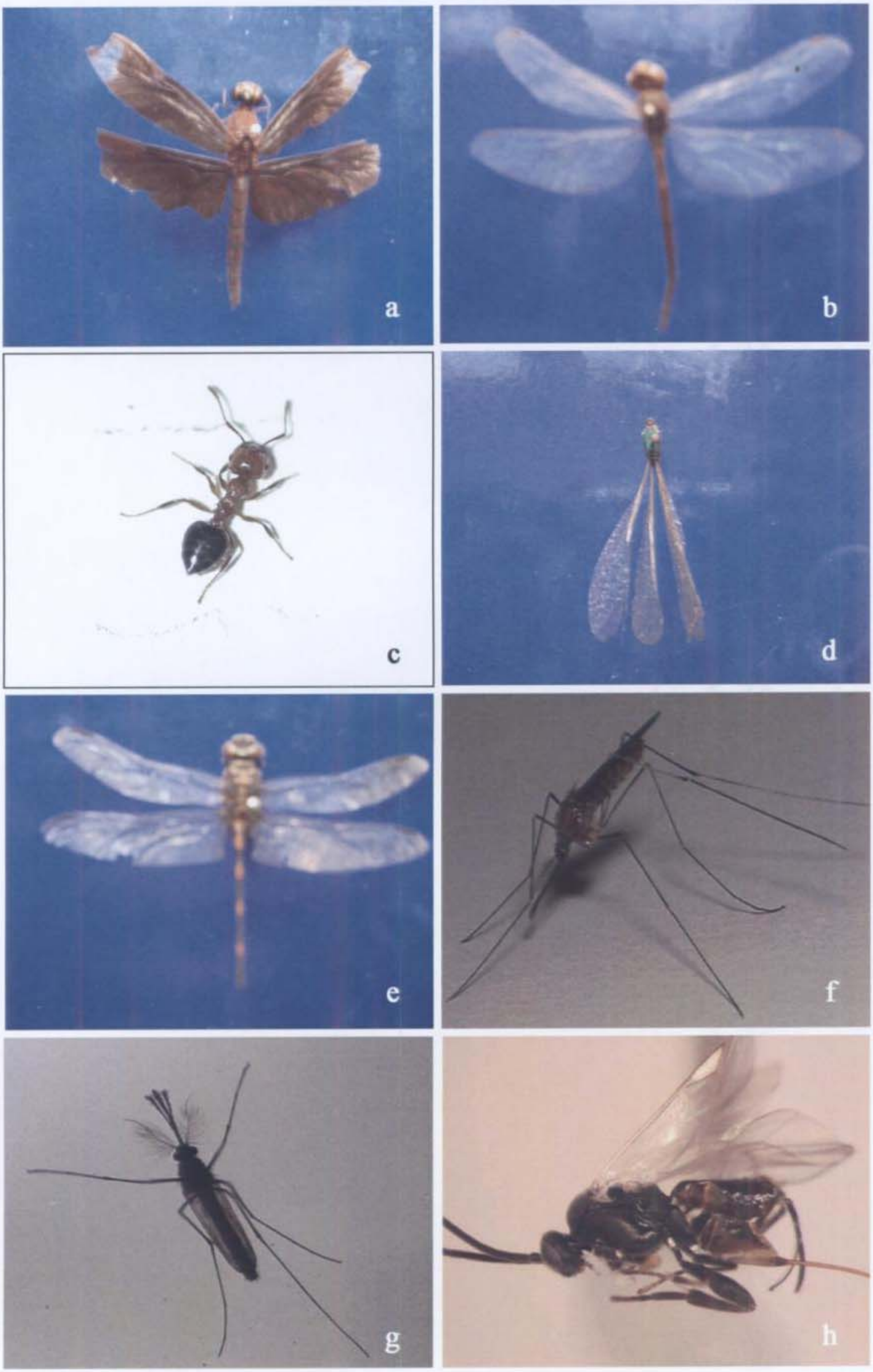


PLATE: 14

a. *Camponotus* species -1

b. *Camponotus* species -2

c. *Monomorium* species -1

d. *Monomorium indicum*

e. *Oecophylla smaragdina*

f. *Pratrechina* species

g. *Solenopsis* species -1

h. *Solenopsis* species -2

i. *Pheidoel* species

j. *Anoplolepis* species

k. *Tetramorium rufonigrum*

l. *Monomorium* species - 2

PLATE 14

PLATE: 15

a. *Scatophagus* species

b. Secutor insidator

c. Stone fish

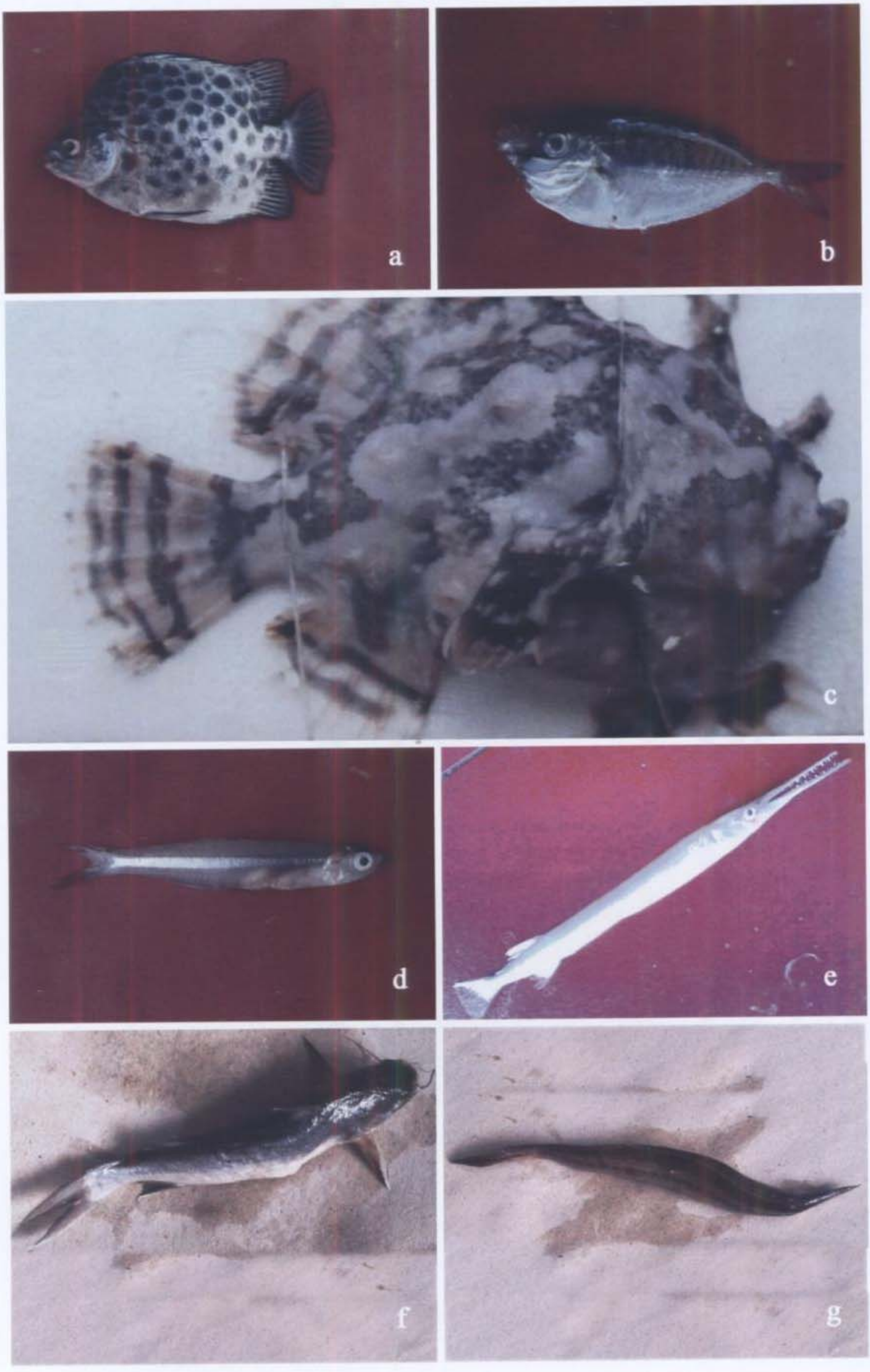
d. Stoliphorus species

e. *Hyporamphus* species

f. *Mystus gul*io

g. *Oxycurichthys tentacularia*

PLATE 15



135 DD

PLATE: 16

a. *Carangoides* species

b. *Carangoides praeustes*

c. *Baracuda* species

d. *Apogon* species

e. *Alepes kleinii*

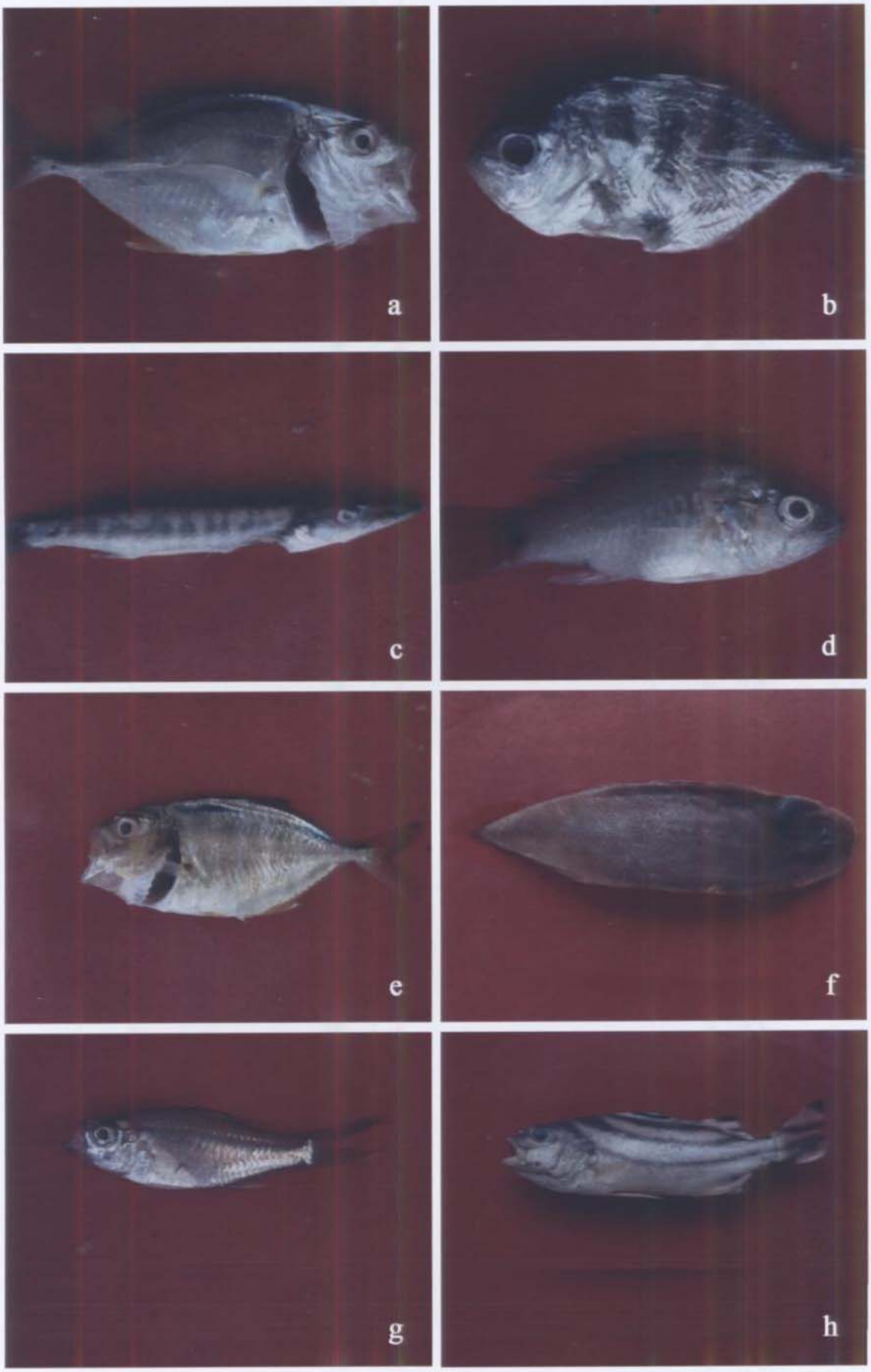
f. *Cynoglossus macrolepidotus*

g. *Ambassis ambassis*

h. *Therapon jarbua*

135EE

PLATE 16



135 FF

PLATE: 17

a. Gerres filamentosus

b. Gobidae species

c. Liza parsia

d. Leognathus incullin

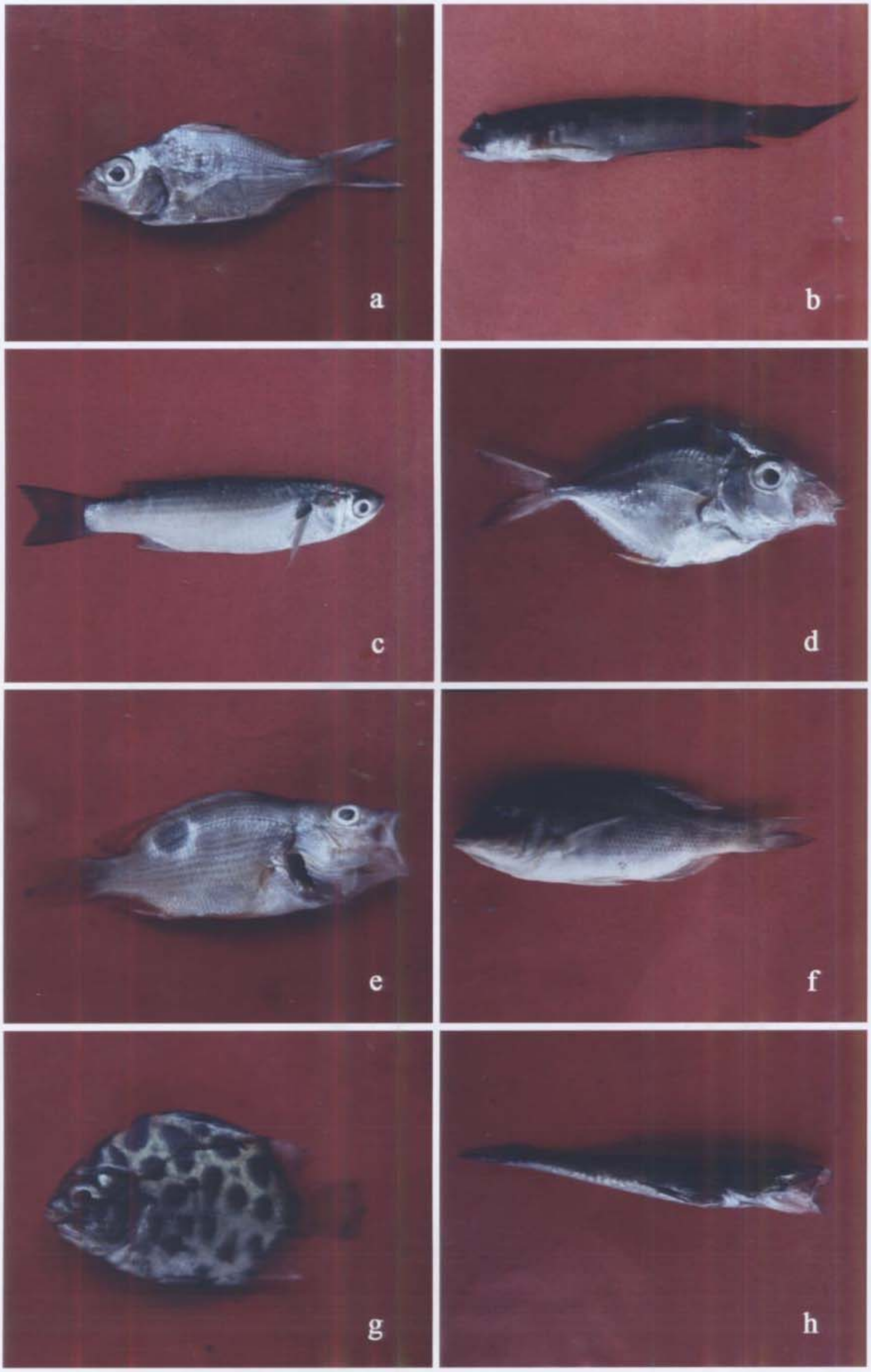
e. Puntius filamentosus

f. Liza parsia

g. Scatophagus argus

h. Saurida tumbil

PLATE 17



135HH

PLATE: 18

a. Herring guli

b. Eurasian curlew

c. Grey egrett

d. Common sandpiper

e. Common red shank

f. Common green shank

g. Sanderlings

h. Pallas gull

52

PLATE 18

135 JJ

PLATE: 19

a. *White necked stork*

b. *Median egrets*

c. *Lesser sand plover*

d. *Lesser spotted eagle*

e. *Lesser crested tern*

f. *Grey plover*

g. *Green sand piper*

h. *Great cormorant*

i. *Greater sand plover*

PLATE 19

135 LL

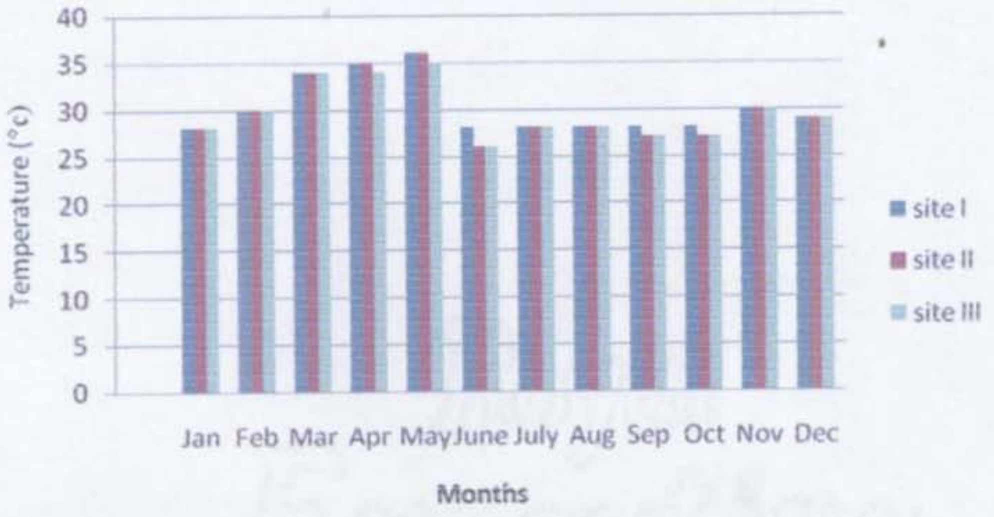


Fig. 1 Atmospheric temperature of the three sites during 2002-03

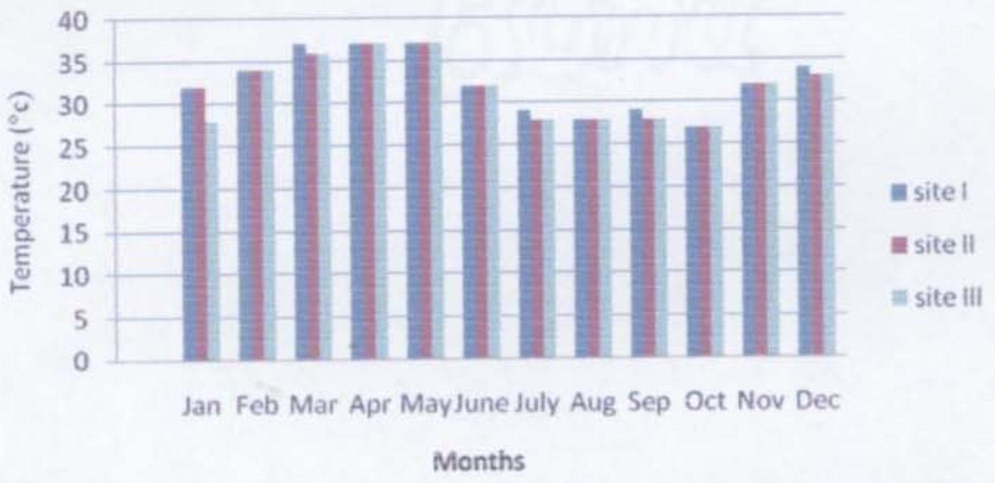


Fig.2. Seasonal variation in the atmospheric temperature of the three sites during 2003-04

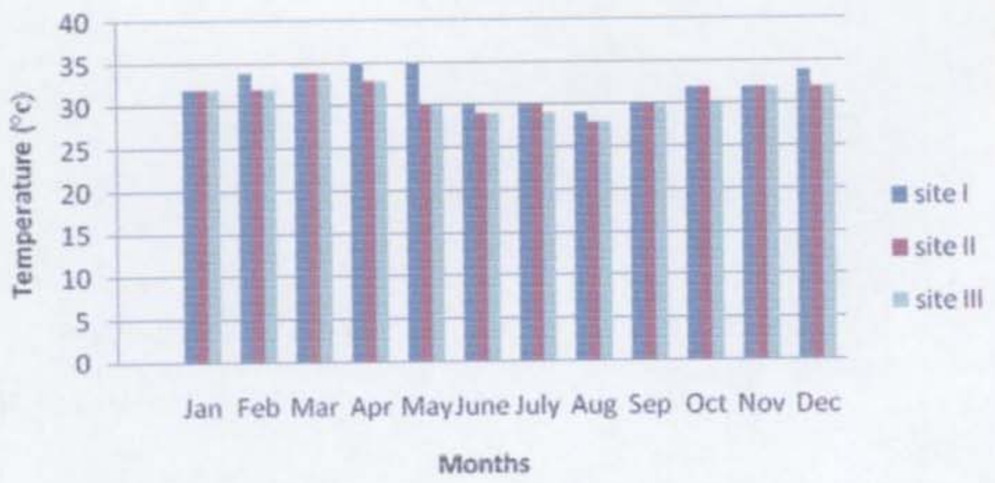


Fig. 3. Seasonal variation in the atmospheric temperature of the three sites during 2004-05

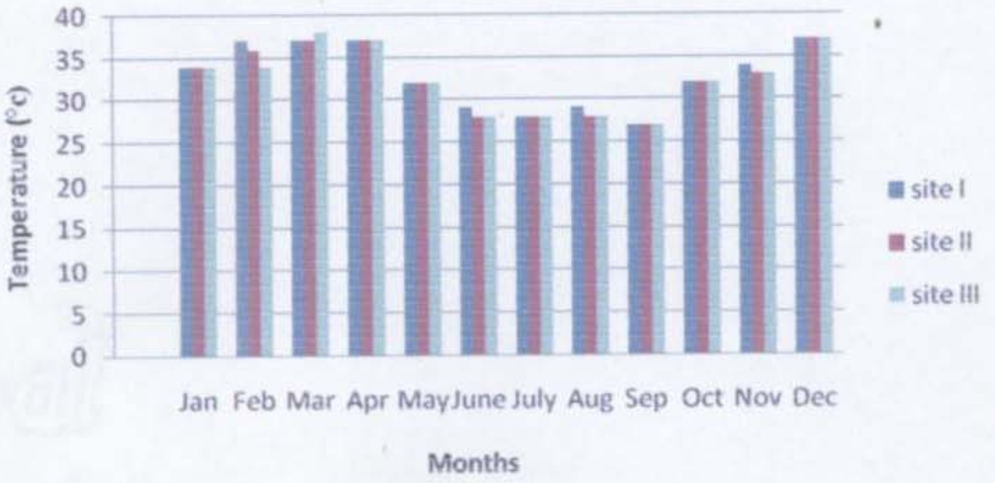


Fig. 4. Seasonal variation in the atmospheric temperature of the three sites during 2005-06

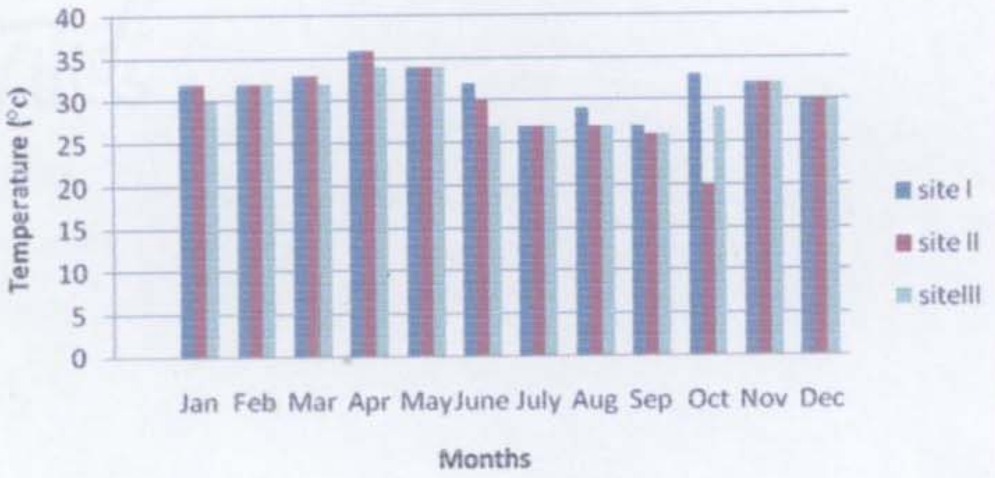


Fig.5. Seasonal variation surface water temperature in the three sites during 2002-03

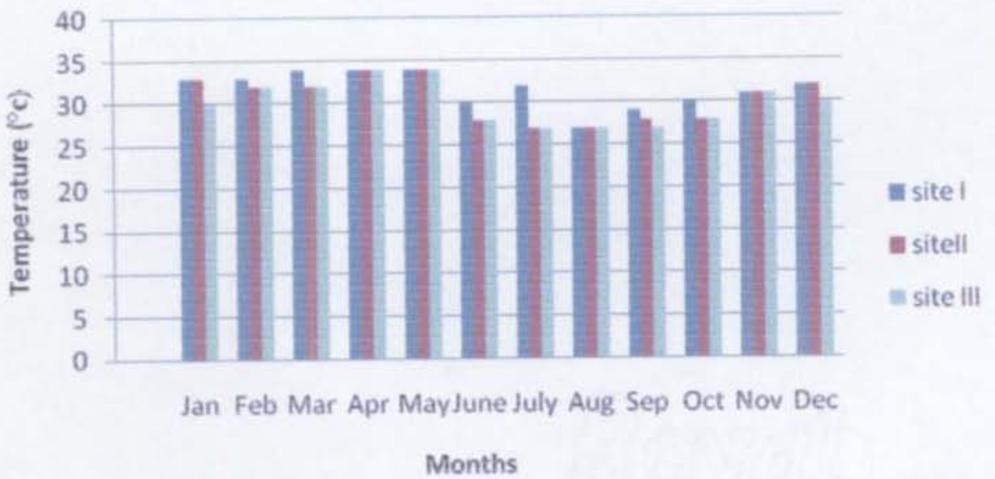


Fig. 6. Seasonal variation in the surface water temperature of the three sites during 2003-04

Fig. 7. Seasonal variation in the surface water temperature in the three sites during 2004-05

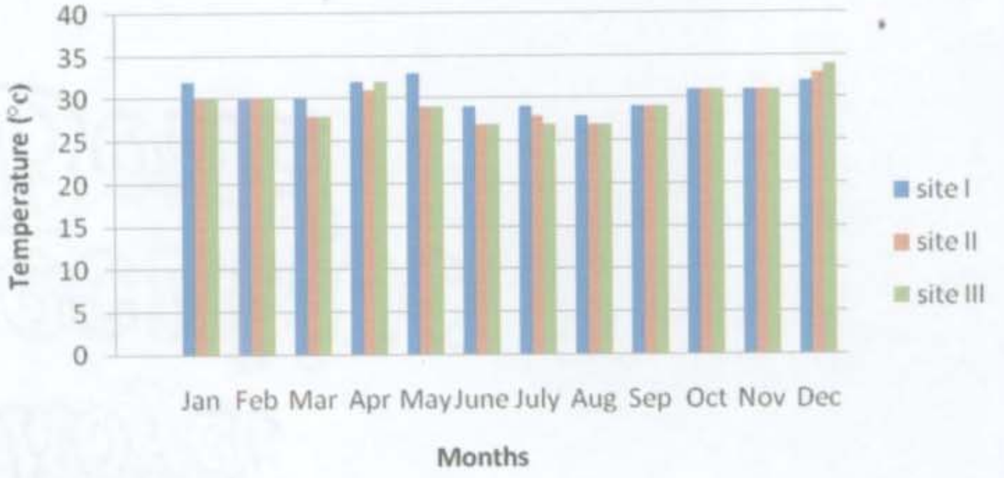


Fig. 8. Seasonal variation in the surface water temperature of the three sites during 2005-06

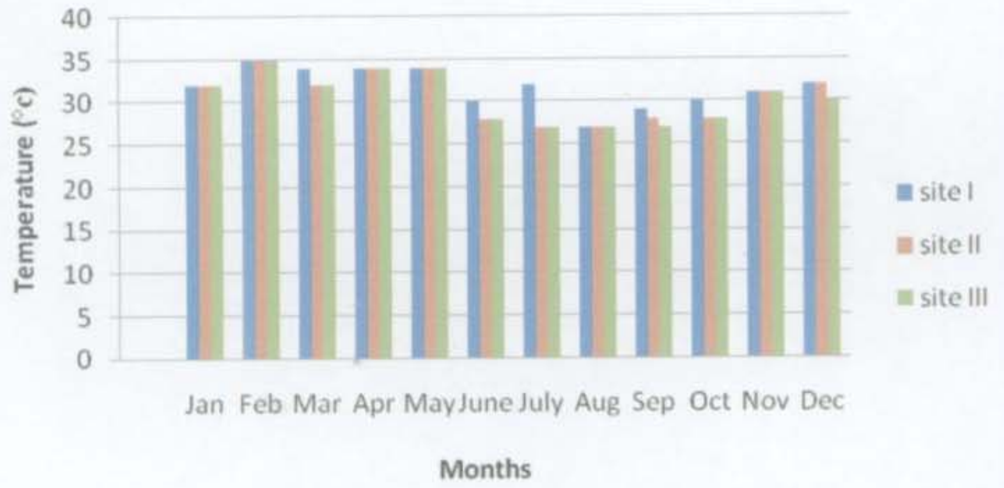


Fig. 9. Seasonal variation in the dipped water temperature o f the three sites during 2002-03

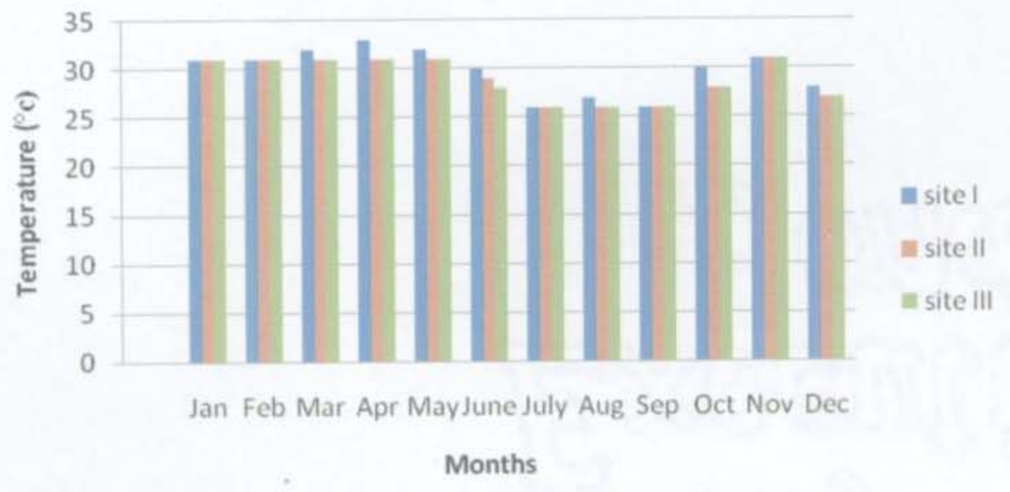


Fig. 10. seasonal variation in the dipped water temprature of the three sites during 2003-04

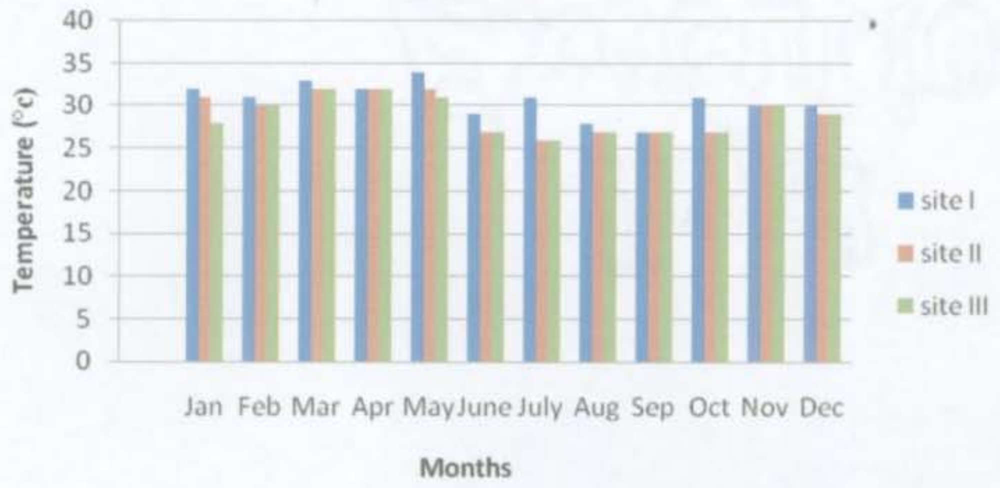


Fig. 11. Seaonal variation in the dipped water emperature of the three sites during 2004-05

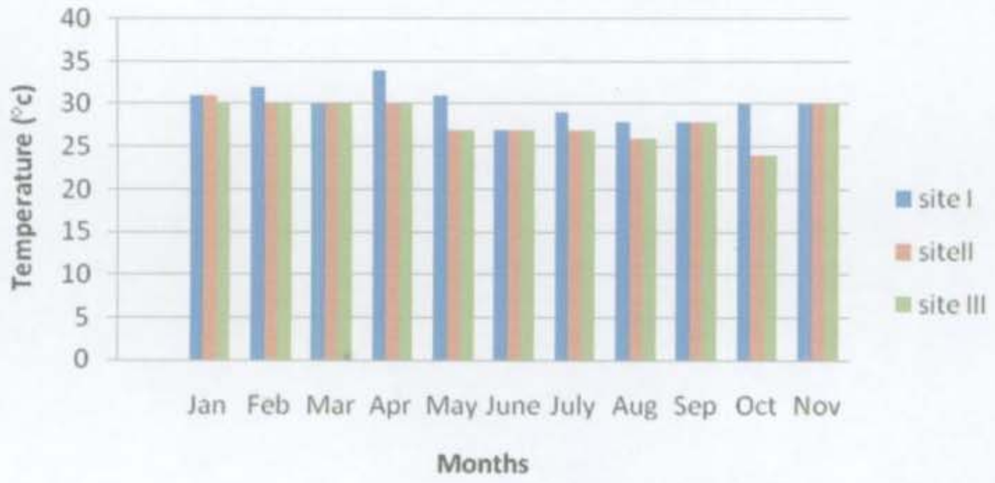


Fig. 12. Seasonal variation in the dipped water temperature of the three sites during 2005-06

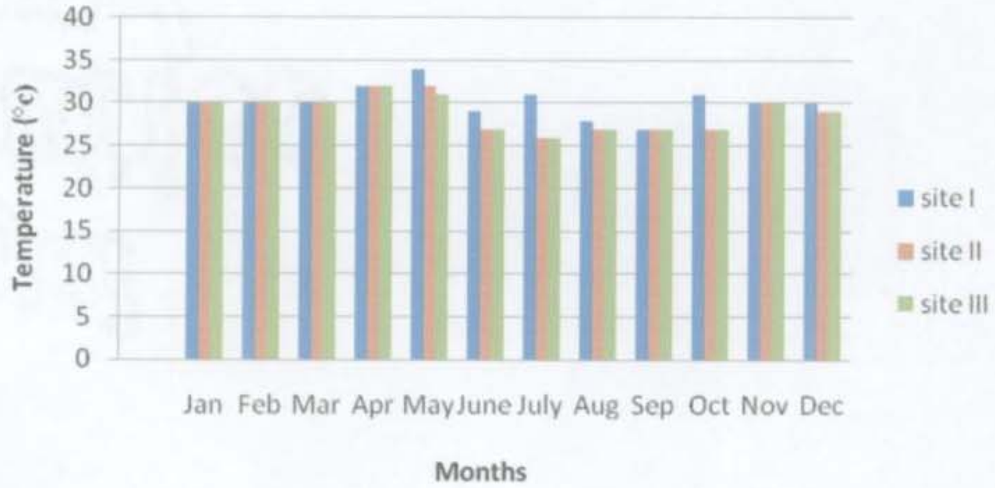


Fig. 13 Seasonal variation in the dissolved oxygen content of the three sites during 2002-03

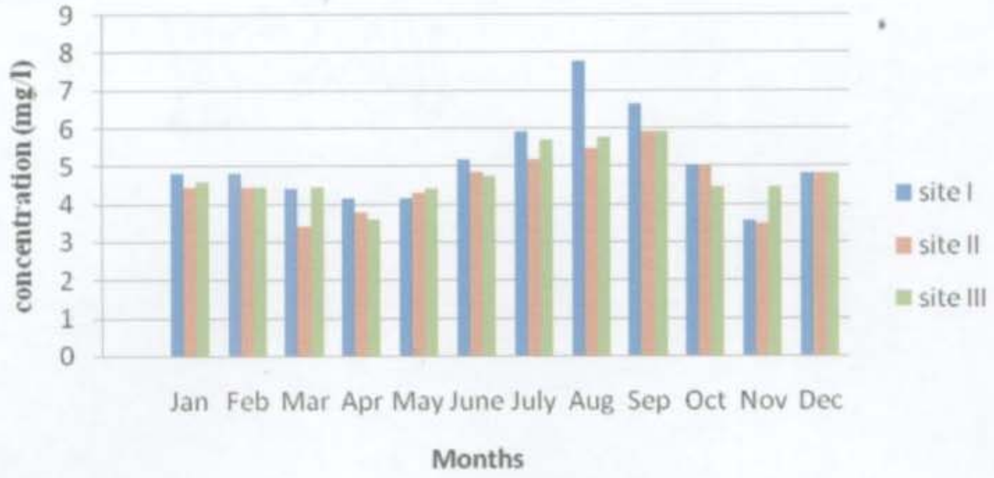


Fig. 14. Seasonal variation in the dissolved oxygen content of the three sites during 2003-04

Fig. 15. seasonal variation in the dissolved oxygen content of the three sites during 2004-05

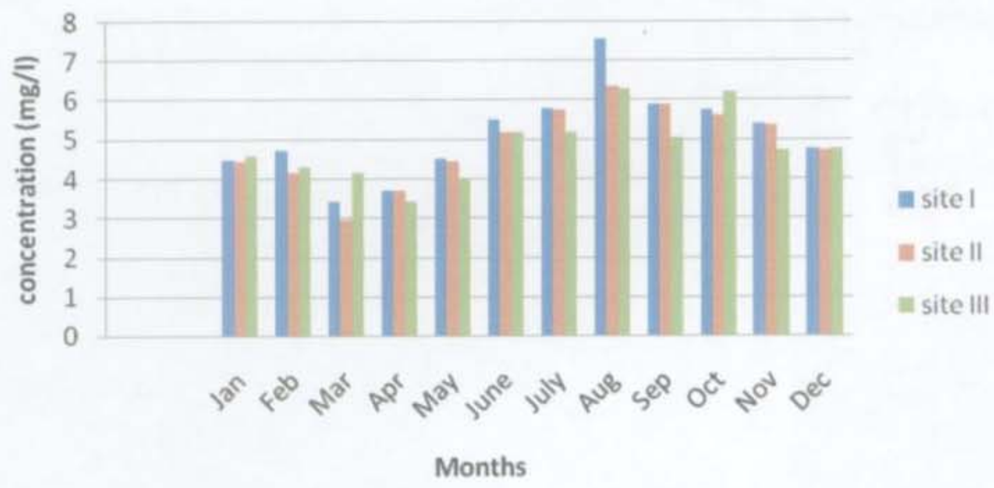


Fig. 16. Seasonal variation in the dissolved oxygen content of the three sites during 2005-06

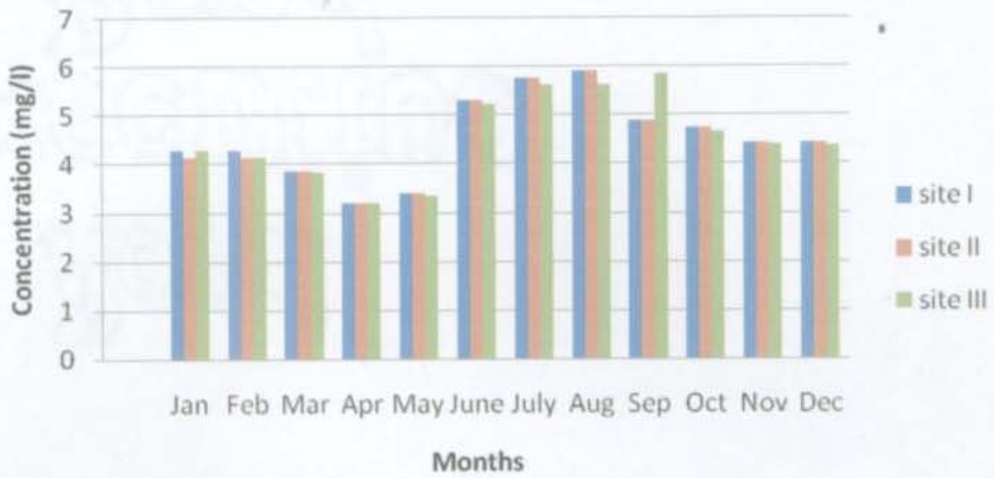


Fig. 17. Seasonal variation in the phosphate content of the three sites during 2002-03

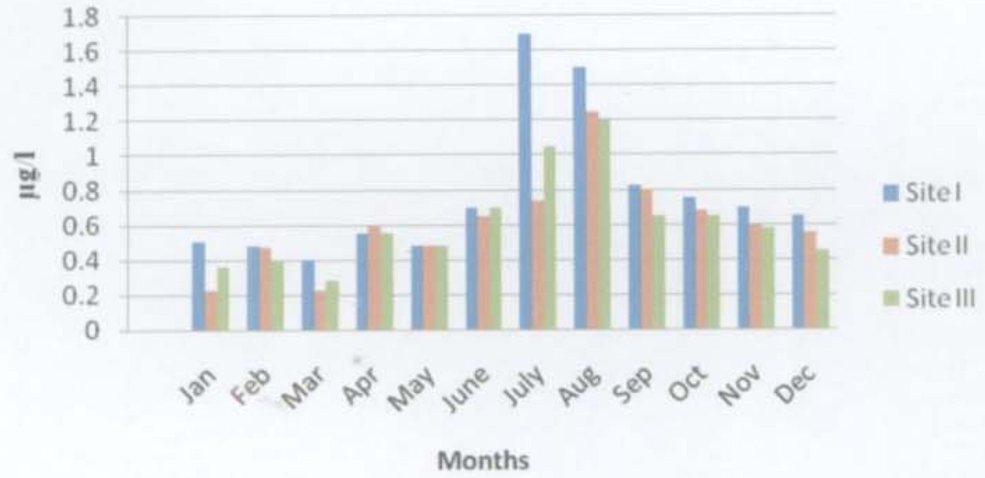


Fig. 18. Seasonal variation in the phosphate content of the three sites during 2003-04

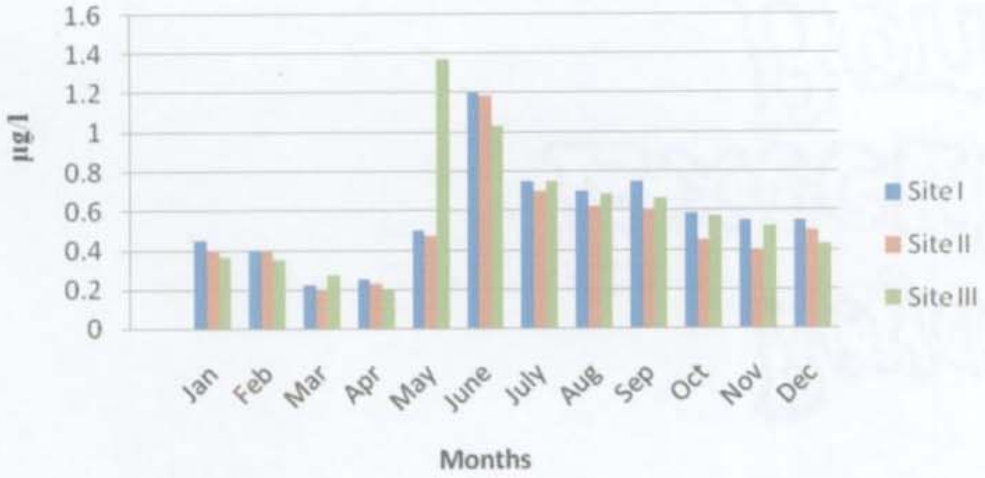


Fig. 19. Seasonal variation in the phosphate content of the three sites during 2004-05

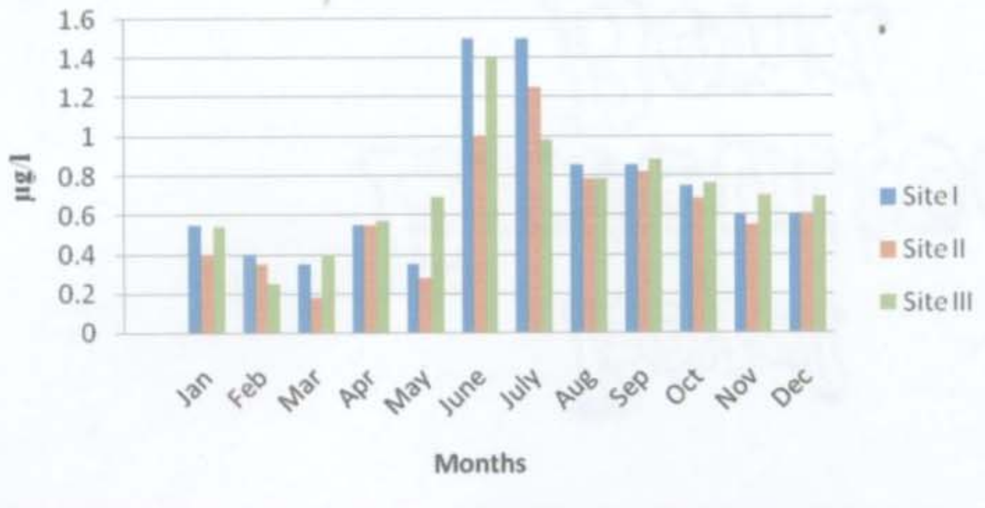


Fig. 20. Seasonal variation in the phosphate content of the thre sites during 2005-06

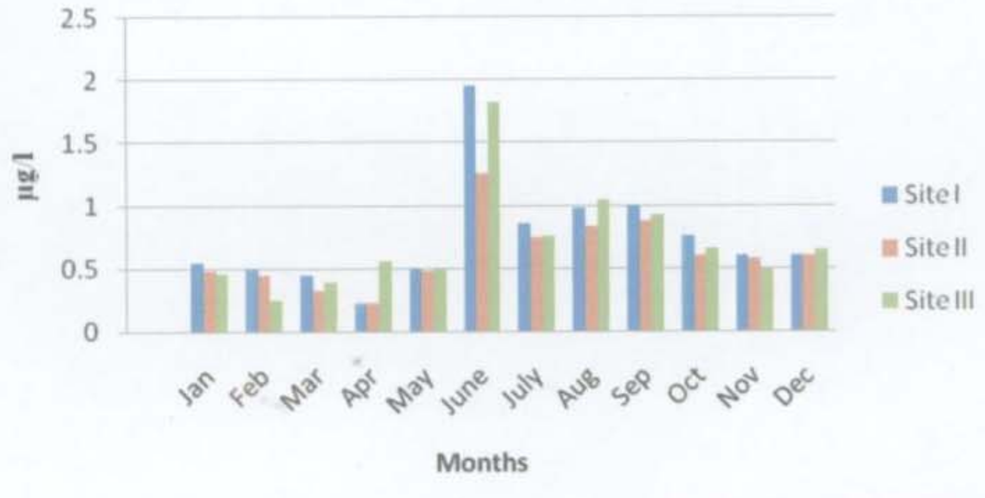


Fig. 21. Seasonal variation in the free carbondioxide content of the three sites during 2002-03

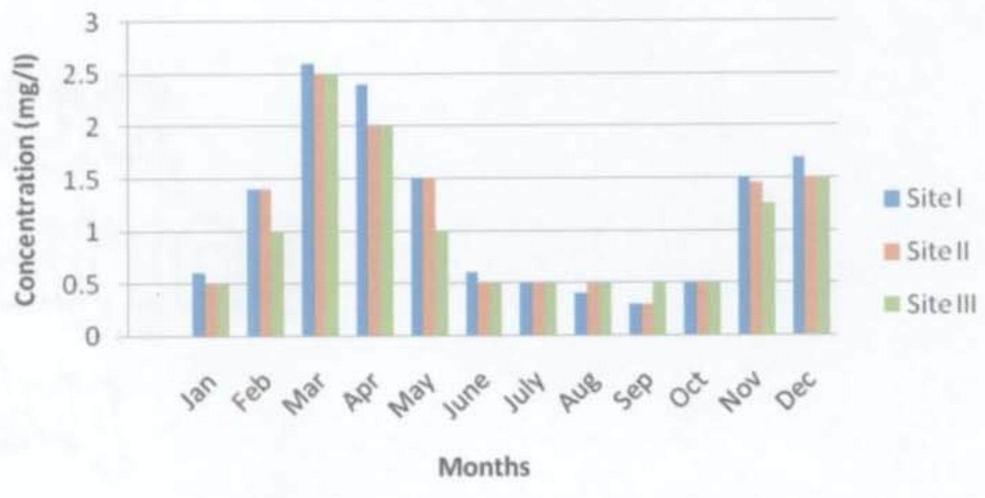


Fig. 22. Seasonal variation in the free carbondioxide content of the three sites during 2003-04

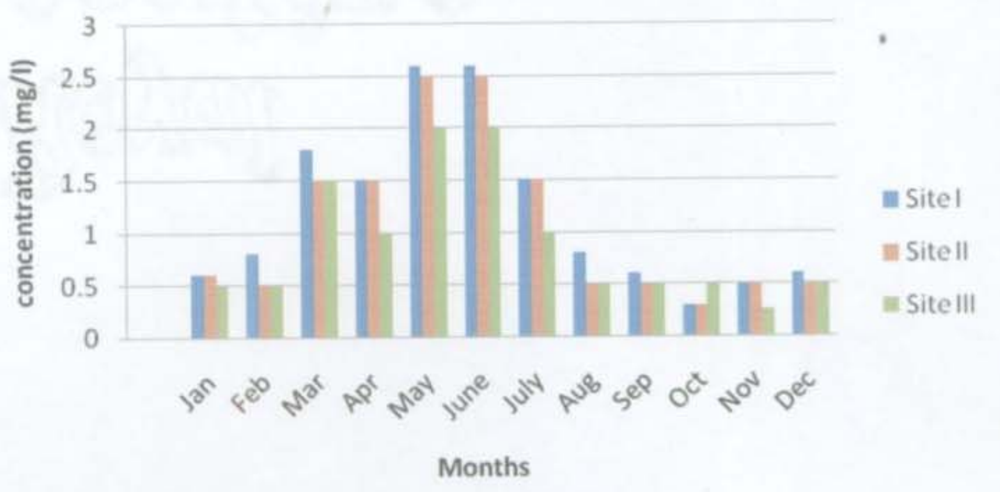


Fig. 23. Seasonal variation in the free carbondioxide content of the three sites during 2004-05

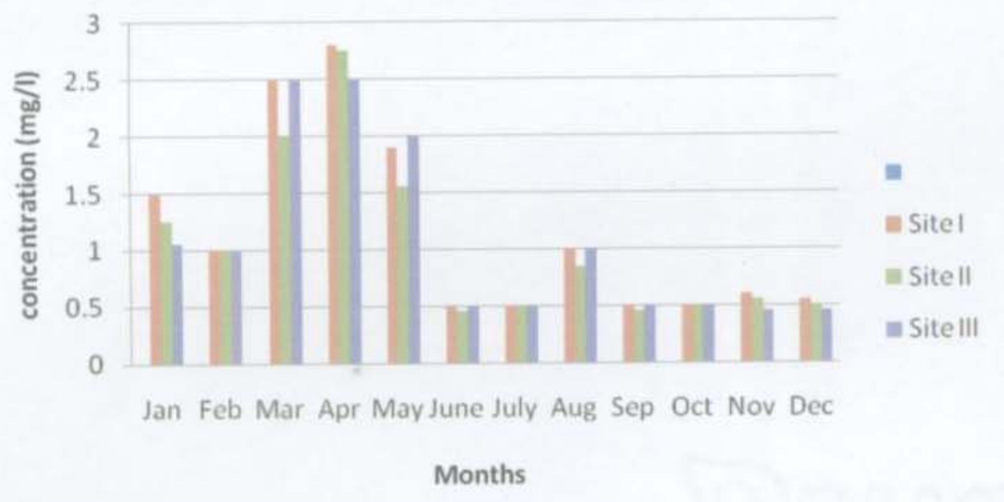


Fig. 24. Seasonal variation in the free carbondioxide content of the three sites during 2005-06

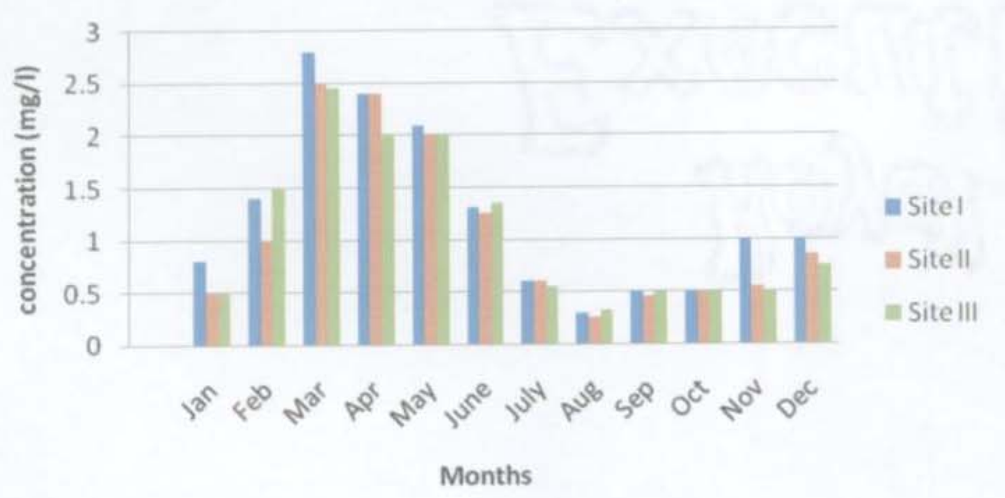


Fig. 25. Seasonal variation in the pH of the three sites during 2002-03

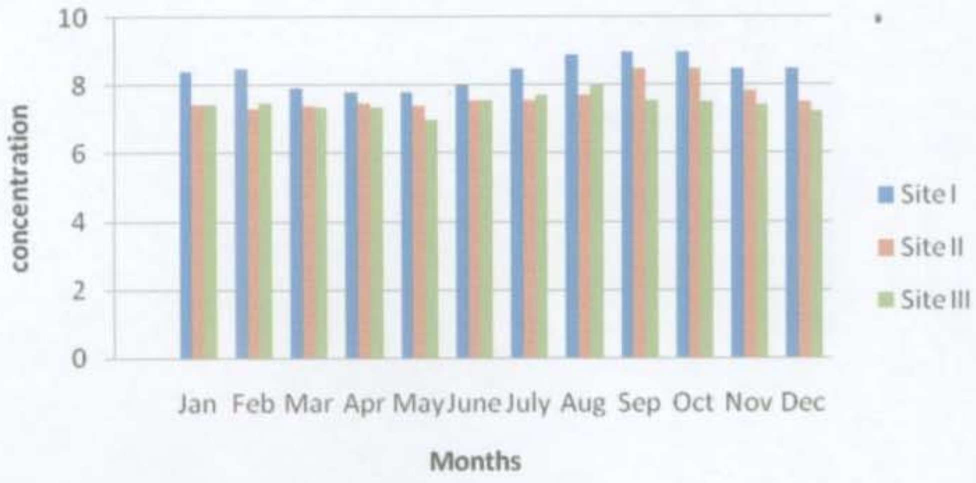


Fig. 26. Seasonal variation in the pH content of the three sites during 2003-04

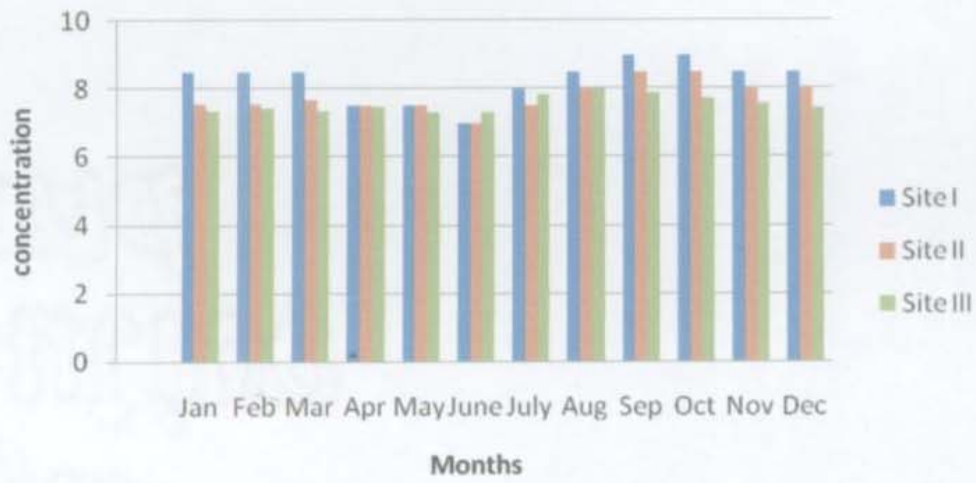


Fig. 27. Seaonal variation in the pH content of the three sites during 2004-05

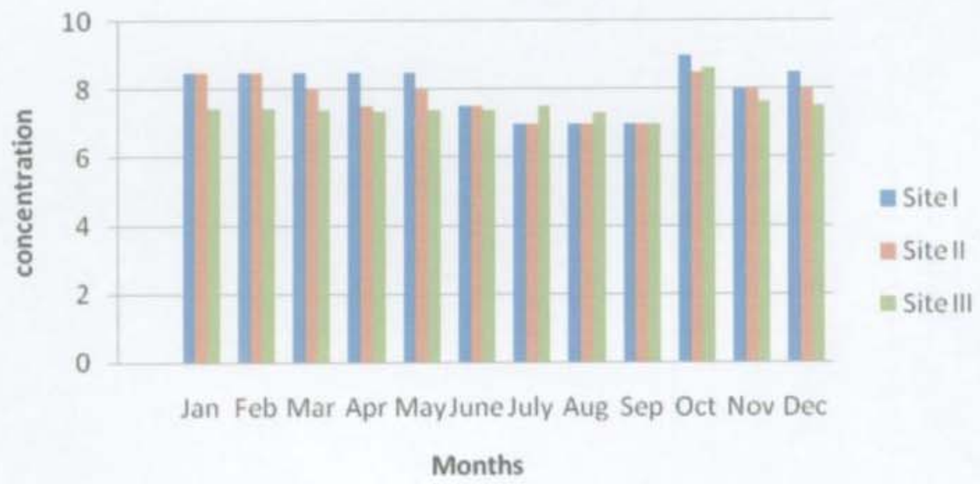


Fig. 28. Seasonal variation in the pH content of the three sites during 2005-06

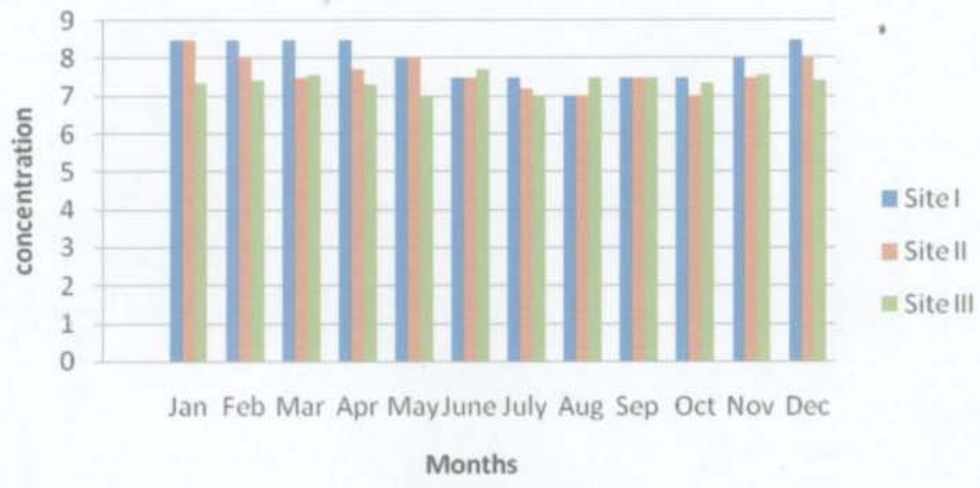


Fig. 29. Seasonal variation in the salinity of the three sites during 2003-04

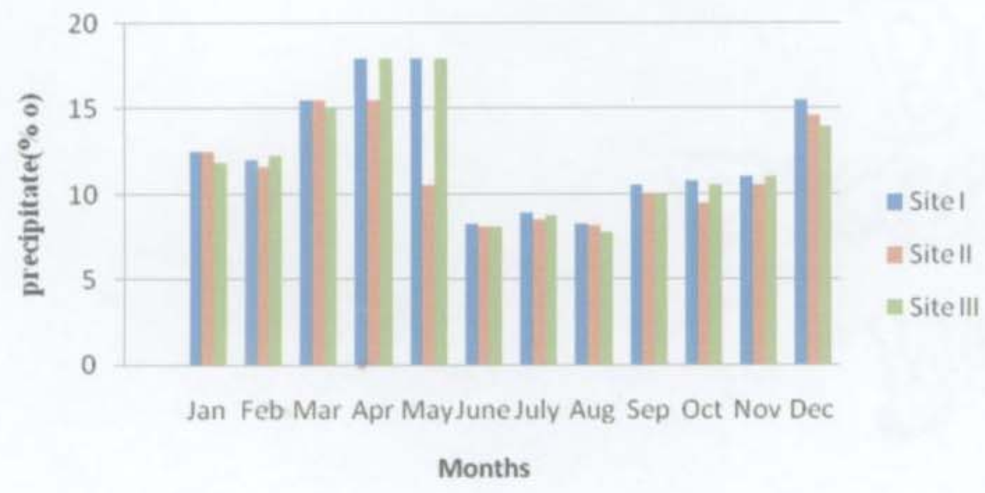


Fig. 30 Seasonal variation in the salinity of the three sites during 2004-05

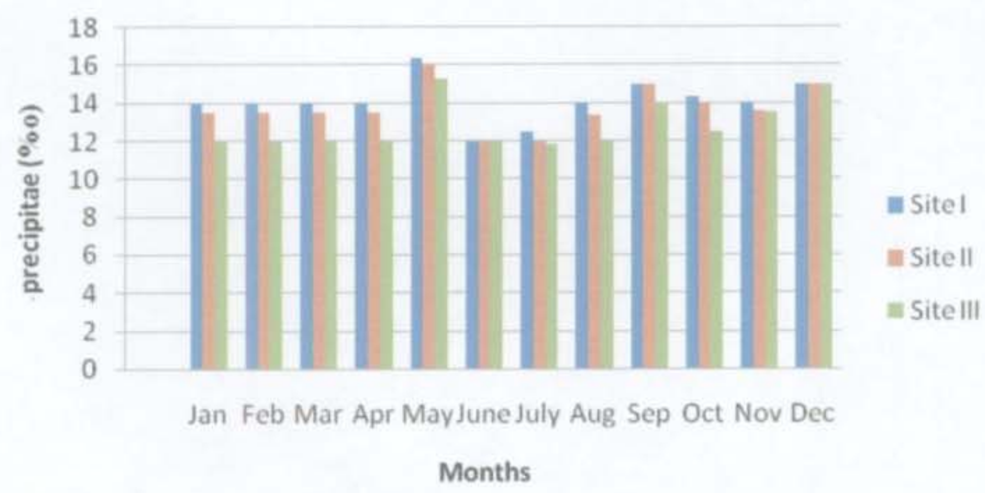


Fig. 31. Seasonal variation in the salinity of the three sites during 2005-06

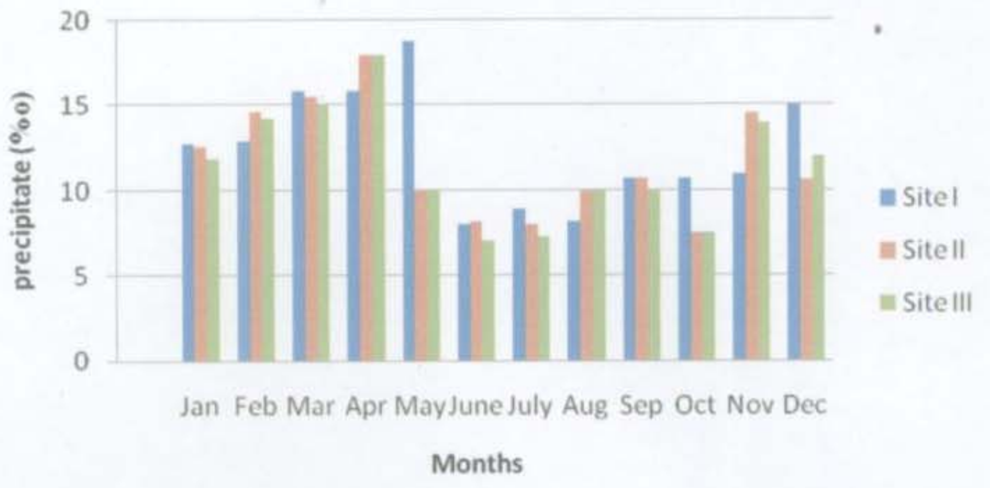


Fig.32. Seasonal variation in zooplankton composition of site I during 2004-05

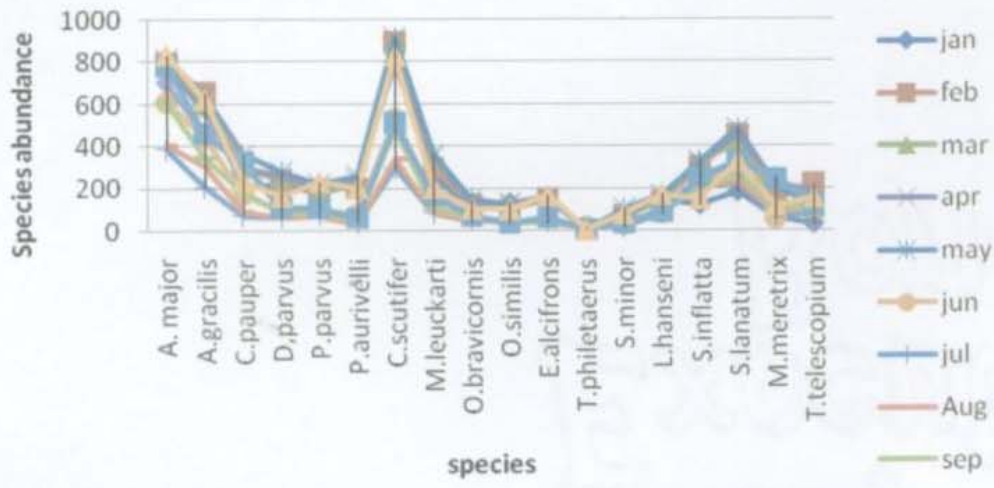


Fig. 33. Seasonal variation in zooplankton composition of site II during 2004-05

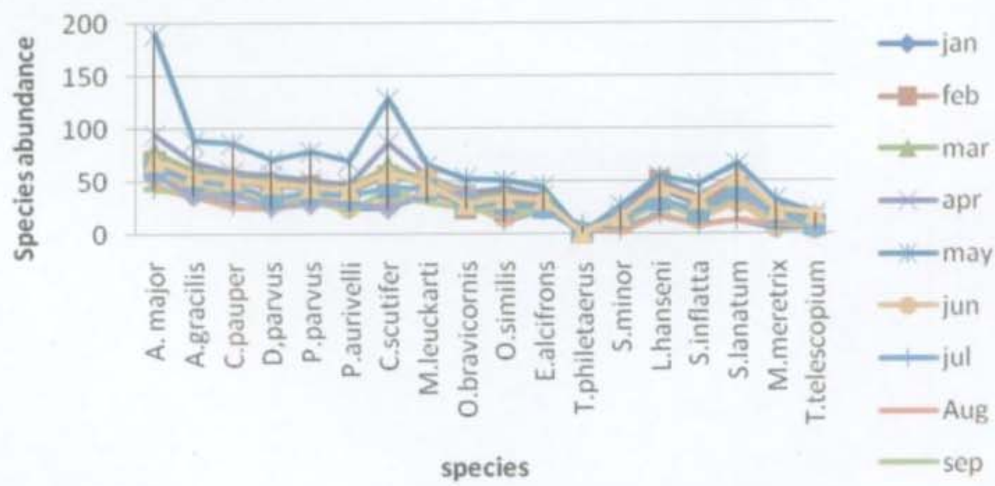


Fig. 34. Seasonal variation in zooplankton composition of site III during 2004-05

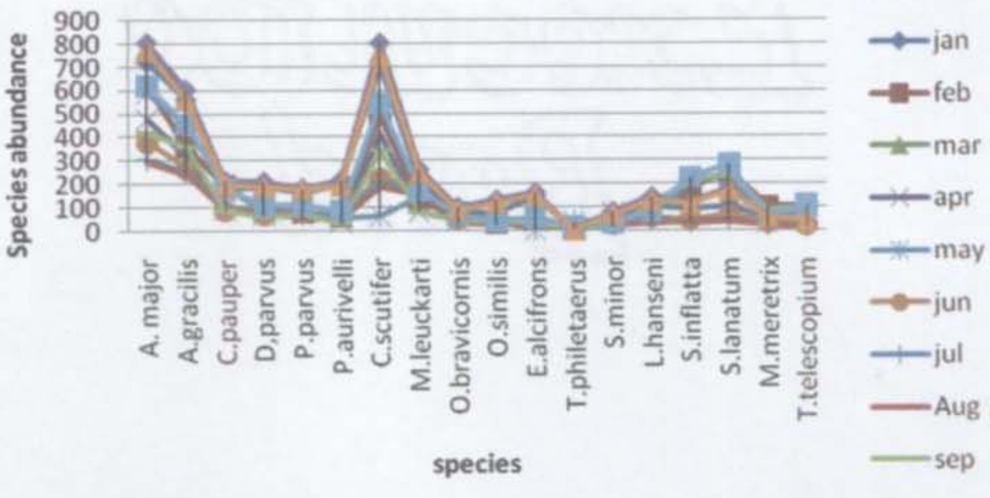


Fig. 35. Seasonal variation in zooplankton composition of site I during 2005-06

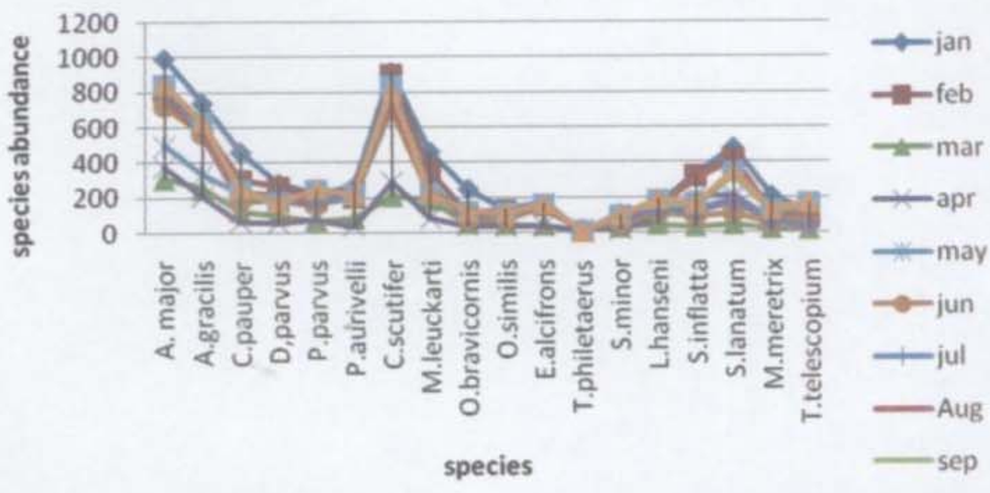


Fig. 36. Seasonal variation in zooplankton composition of site II during 2005-06

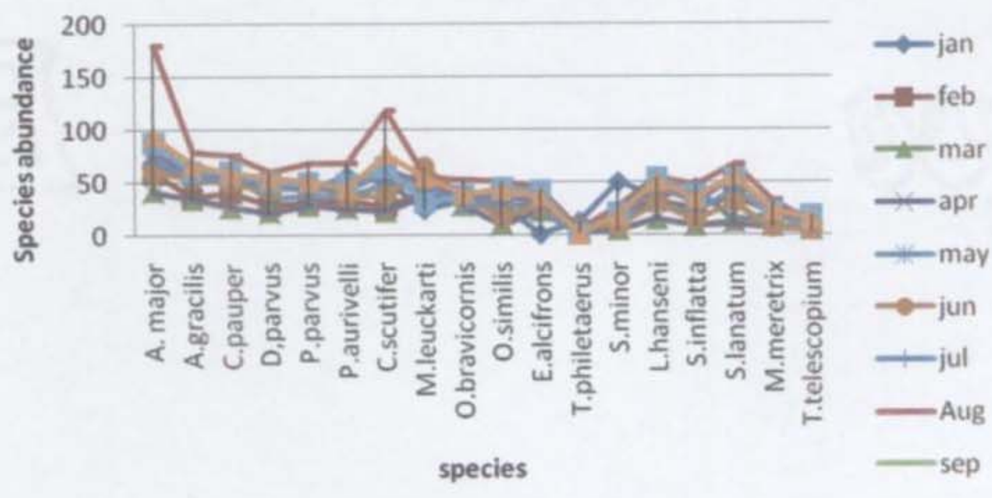


Fig. 37. Seasonal variation in zooplankton composition of site III during 2005-06

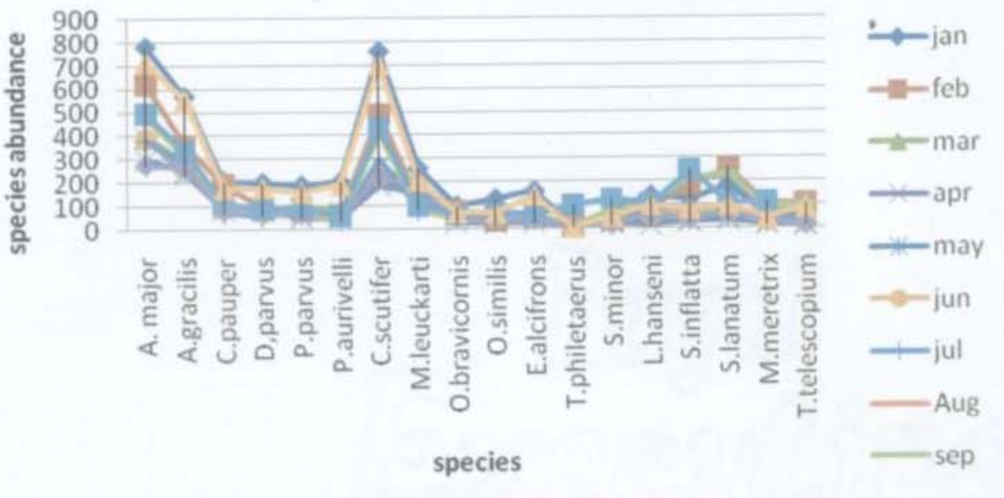


Fig. 38. Seasonal variation in crab composition of site I during 2004-05

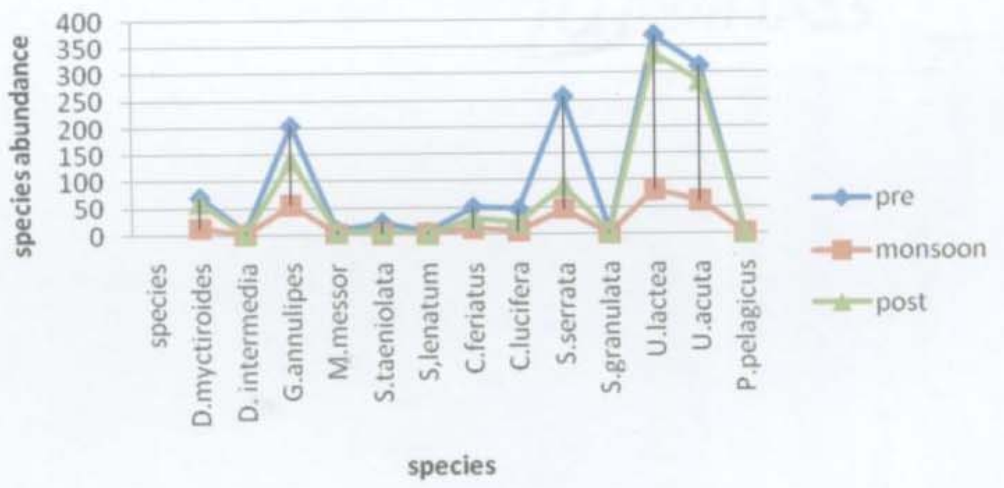


Fig. 39. Seasonal variation in crab composition of site II during 2004-05

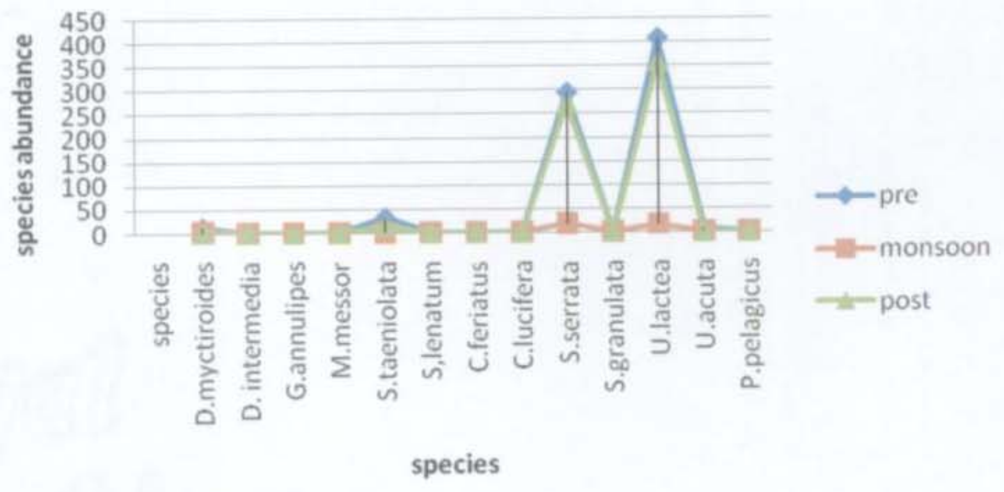


Fig. 40. Seasonal variation in crab composition of site III during 2004-05

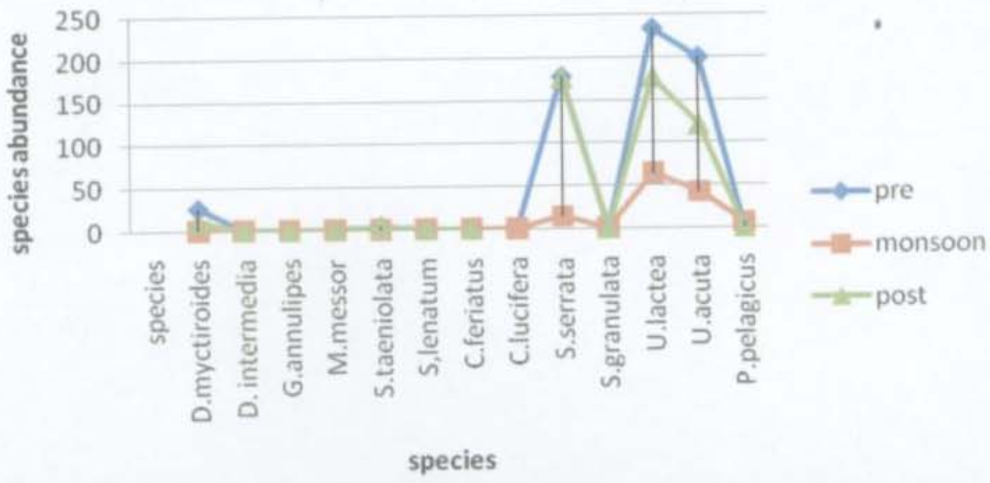


Fig. 41. Seasonal variation in crab composition of site I during 2005-06

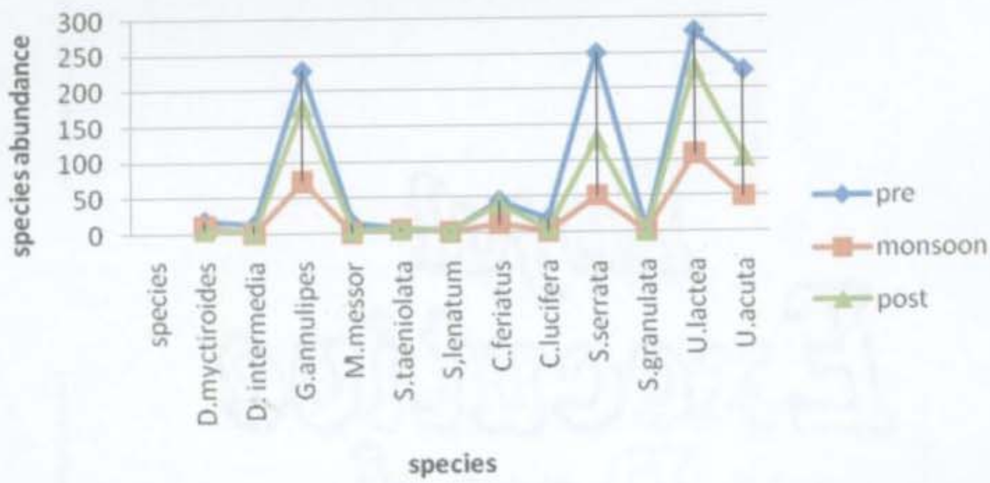
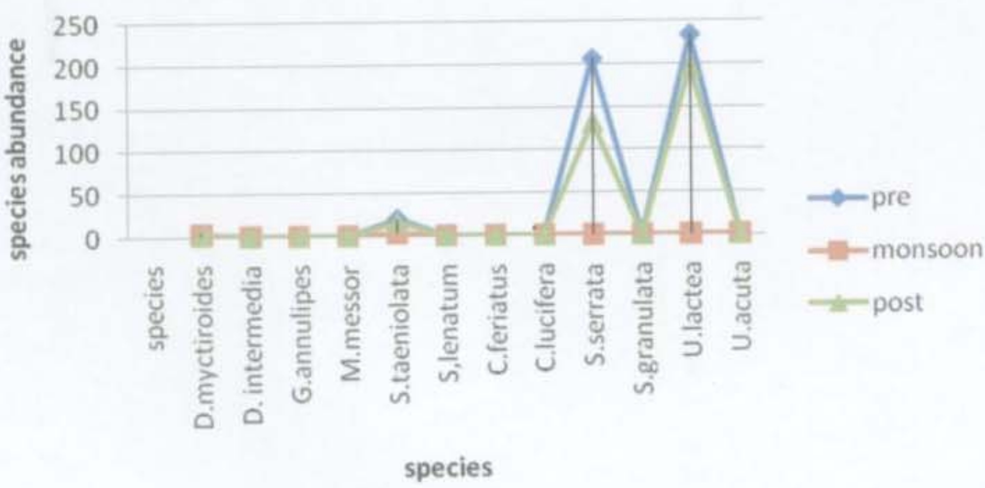


Fig. 42. Seasonal variation in crab composition of site II during 2005-06



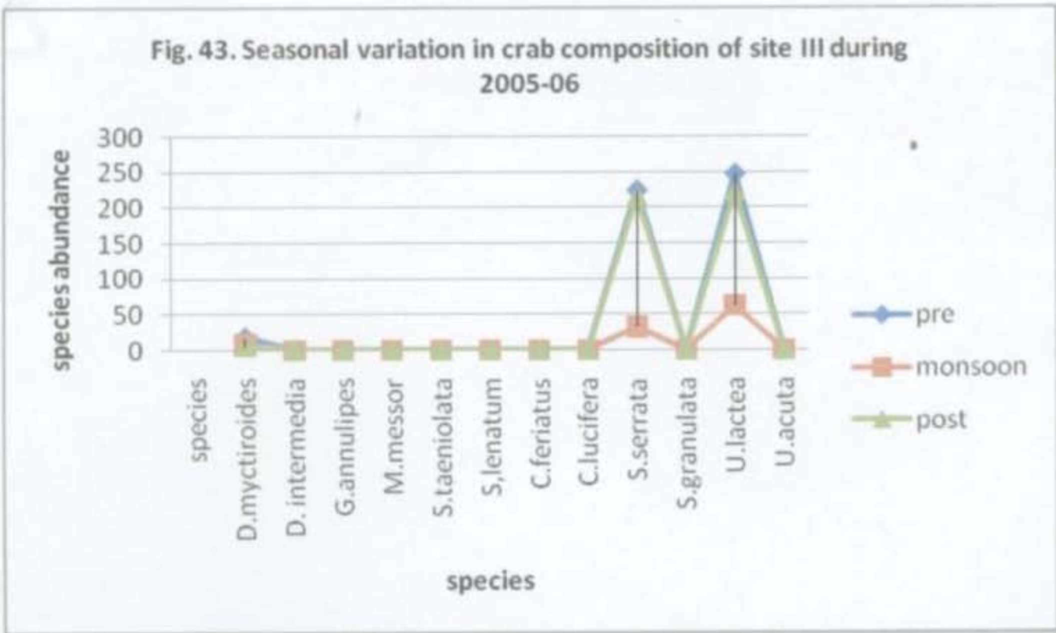


Fig. 43. Seasonal variation in crab composition of site III during 2005-06
species abundance
300
250
200
150
100
50
0
species
D.myctiroides
D. intermedia
G.annulipes
M.messor
S.taeniolata
S,lenatum
C.feriatus
C.lucifera
S.serrata
S.granulata
U.lactea
U.acuta
species
pre
monsoon
post

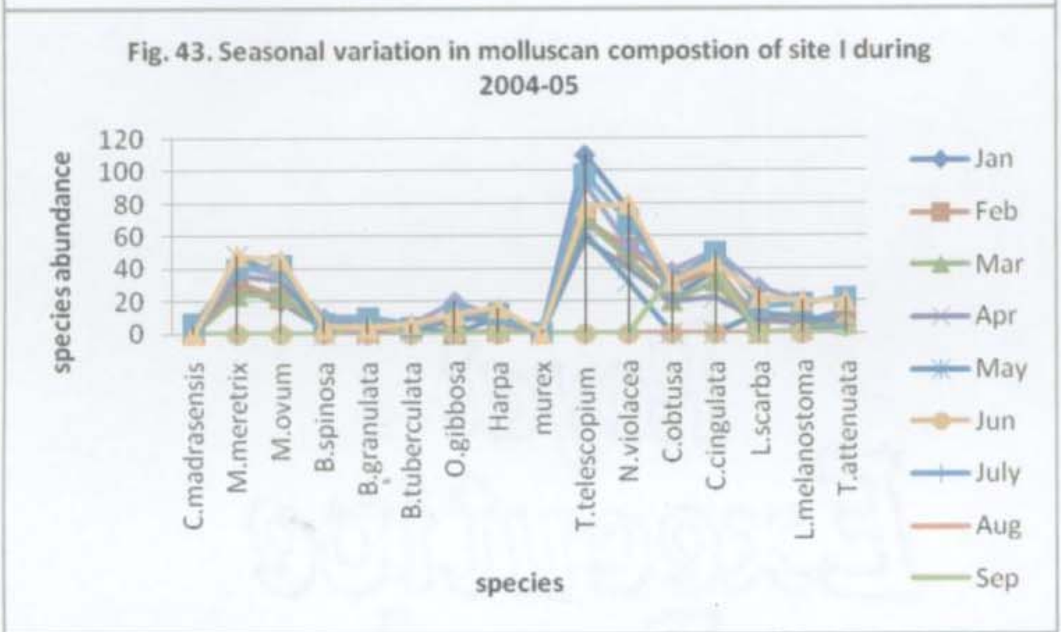


Fig. 43. Seasonal variation in molluscan compostion of site I during 2004-05
species abundance
120
100
80
60
40
20
0
C.madrasensis
M.meretrix
M.ovum
B.spinosa
B.granulata
B.tuberculata
O.gibbosa
Harpa
murex
T.telescopium
N.violacea
C.obtusa
C.cingulata
L.scarba
L.melanostoma
T.attenuata
species
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sep

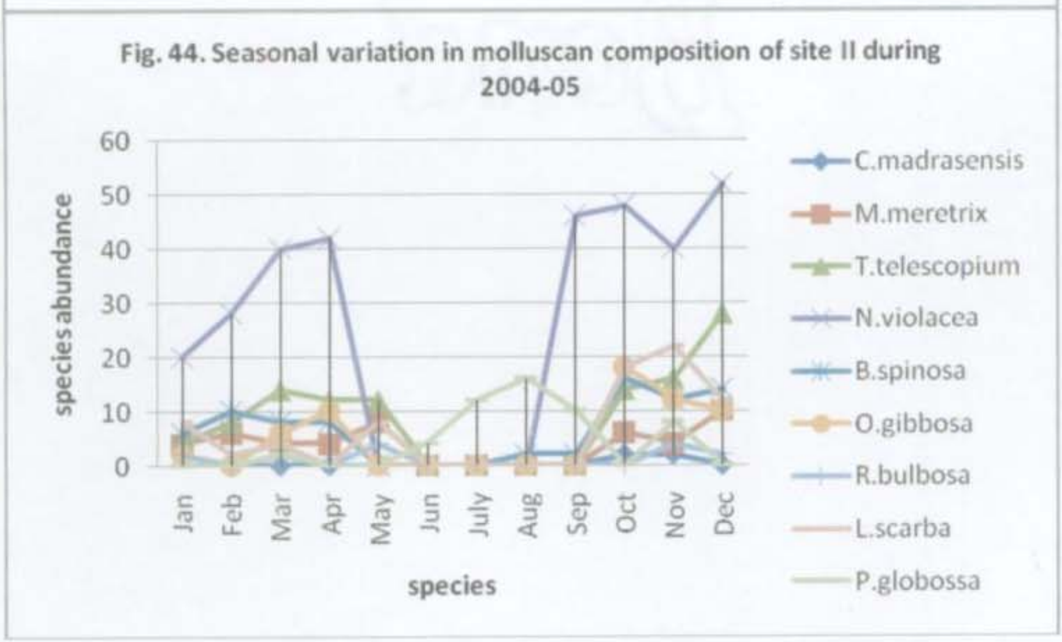


Fig. 44. Seasonal variation in molluscan composition of site II during 2004-05
species abundance
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sep
Oct
Nov
Dec
species
C.madrasensis
M.meretrix
T.telescopium
N.violacea
B.spinosa
O.gibbosa
R.bulbosa
L.scarba
P.globossa

Fig. 45. Seasonal variation of mollusan composition of site III during 2004-05

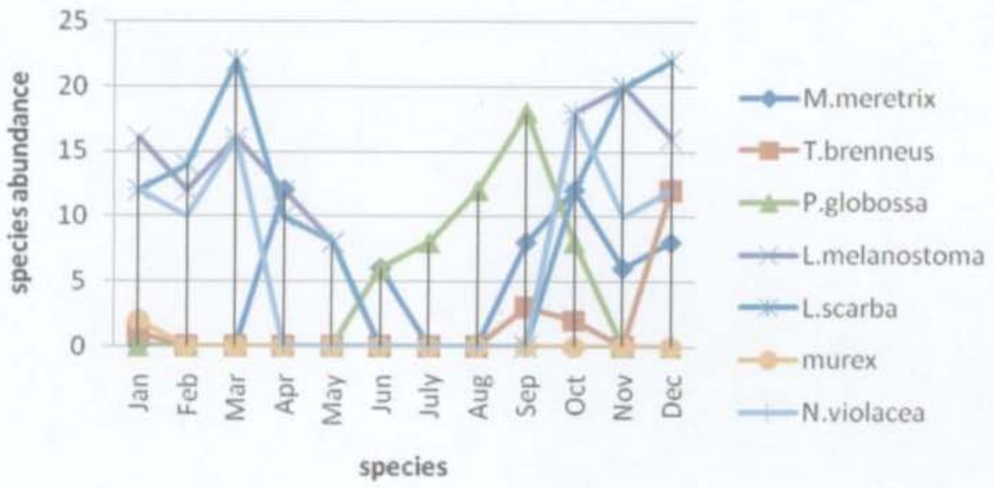


Fig. 46. Seasonal variation in molluscan composition of site I during 2005-06

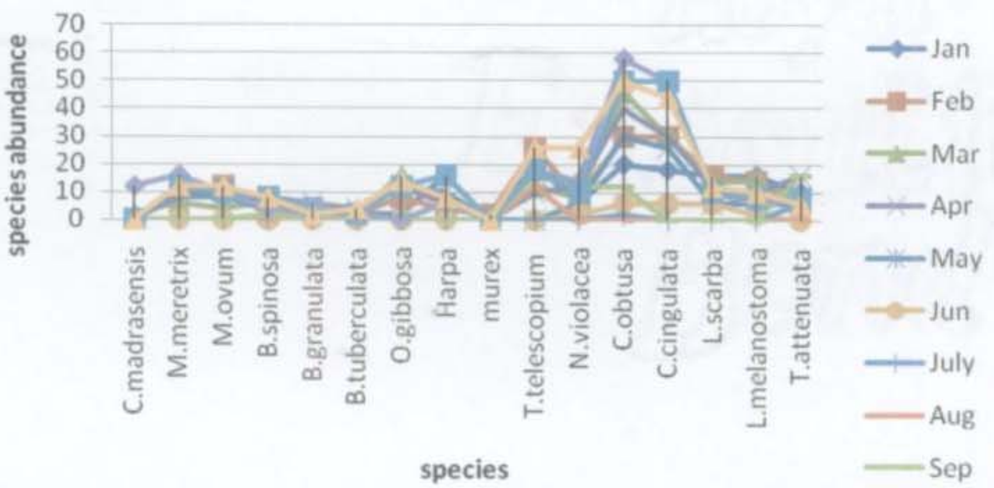
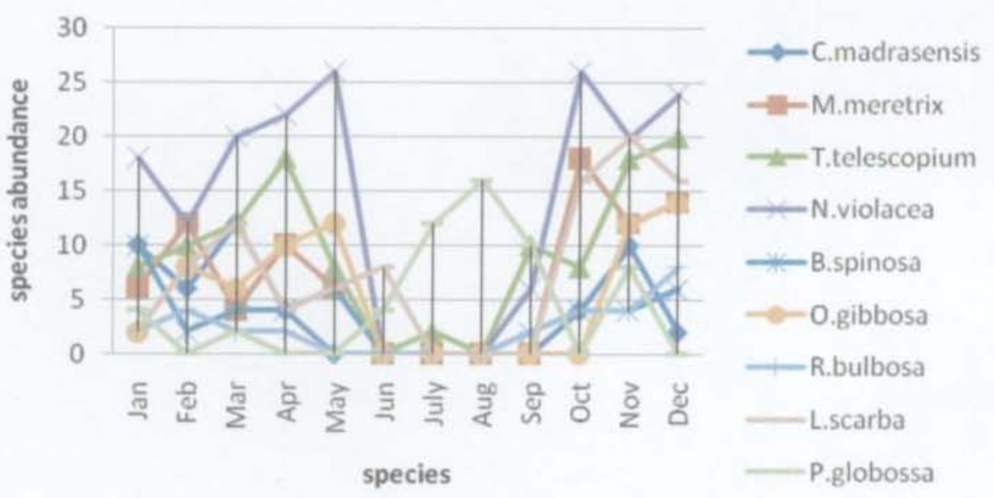


Fig. 47. Seasonal variation in molluscan composition of site II during 2005-06



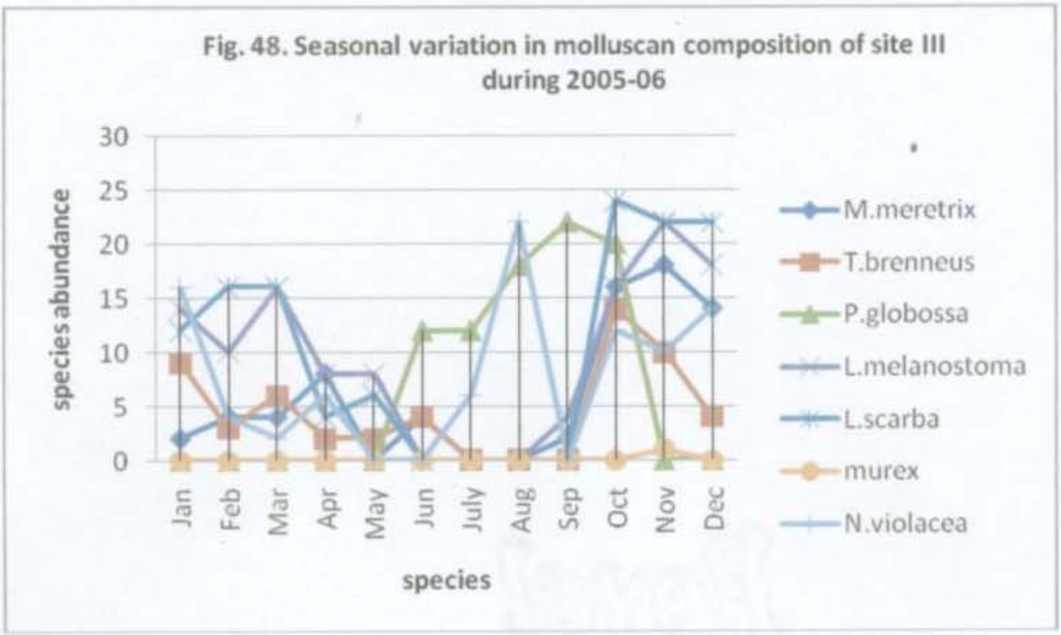


Fig. 48. Seasonal variation in molluscan composition of site III during 2005-06
species abundance
30
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sep
Oct
Nov
Dec
species
M.meretrix
T.brenneus
P.globossa
L.melanostoma
L.scarba
murex
N.violacea

DISCUSSION

DISCUSSION

CHAPTER - V

DISCUSSION

The climate over the state is of a tropical monsoon type with seasonally excessive rainfall and hot summer. The period from March to May is the hot season. It is followed by the southwest monsoon that continues till the middle of October, and then commences the north east monsoon that lasts up to the end of February. The state experiences copious rain, major part of which is received during the south east monsoon from June to September.

Kadalundi and Nalallam mangrove systems undergo important hydrobiological changes during monsoon months, similar to other estuaries. The occurrence of temperature minimum and maximum coincided with seasonal changes of that area and consequent inflow of fresh water. Throughout the study period seasonal variation in atmospheric temperature, surface water temperature and dipped water temperature was maximum during premonsoon and there was a decrease during monsoon in all the three sites. This may be due to the increased fresh water inflow during monsoon season or the high temperature during premonsoon can be attributed to high solar radiation, which agrees with the observation made by Vijayalakshmi et al., (1983); Thangaraj (1984); Kondala (1984); Goswami and Devassy (1991); Ramanathan et al., (1993); Lalithambikadevi (1993 during their studies on ecobiology of marine zones of south east coast. The slight decrease of water temperature observed with depth during the present study may be due to the heating effect of the sun on the surface water and the transference of heat throughout the water column by mixing process. Saad (1977) during the study on seasonal variations of some physico-chemical conditions of Shatt al-Arab estuary; Chandran and Ramamoorthi (1984) and Ramanathan et al., (1993) while studying the geochemistry of Vellar estuary and Ricardo et al., (2002) while estimating the mean temperature and salinity of the Chesapeake Bay mouth estuaries have also made similar observations. They opined that the low surface temperature may be due to less incident radiation. Contradictory to these observations Gupta et al., (1980) observed warmer subsurface waters due to the influx of warmer tidal water in Nethrapur-Gurupur estuary.

Dissolved oxygen at all the three study sites showed higher values during monsoon season during the duration of the study, which may be due to renewal of fresh water inflow. Dehadrai (1970) and Haridas et. al. (1973) have also opined that oxygen in the estuarine environment is chiefly controlled by tidal ingress and fresh water runoff and higher oxygen values were obtained during monsoon. During this time the decomposition rate may be less due to the lower temperature and the solubility of oxygen in the water will be high. The lowest dissolved oxygen value recorded during the present study from all the three sites during premonsoon may be due to the fact that decomposition rate is high as opined by Banargee and Choudhury (1966); Dehadrai (1970); Singbel (1973) and Haridas et al., (1973) during their studies on physico-chemical parameters of south west coasts of India.

Phosphate concentration showed quite distinct seasonal variation and high values during monsoon as seen in the case of oxygen. Significant seasonal variation of phosphate concentration throughout the study period warrants an understanding of the fresh water discharge which forms the major source of nutrient supply. The nature and extent of fresh water discharge is chiefly controlled by the regime of precipitation during monsoon season. Fluctuations in concentration were visible with high concentration in monsoon (June-September) and relatively low concentration during premonsoon (February – May). Similar seasonal variations were observed by Singbel (1973) in Goa and Synudheen (2004) in Kerala. Ashok et al., (2005) during their studies on Parangipettai mangroves have stated that the distribution and behavior of nutrients in the coastal environs would exhibit considerable seasonal variations depending upon local conditions like rainfall pattern and quantity of freshwater inflow. A high concentration of phosphates during monsoon was also reported by Sankaranarayanan and Qasim (1969) in Cochin backwaters and Dehadrai (1970) in Zuari and Mandovi. Studies carried out in Vellar estuaries by Krishnamurthy (1970); Ramadhas (1977); Chandran (1982) and Vijayalakshmi and Venugopalan (1973) also agrees with the present observation. These authors also recorded low phosphate values during the summer and early pre-monsoon months. But Haridas et al. (1973); Nair et al., (1983) and Rajagopal and Reddy, (1984) have obtained lower phosphate in the estuarine environment during monsoon and have attributed it to greater silt load and high turbid conditions resulting in removal of phosphorous from solution.

Maximum value of free carbondioxide during premonsoon and the minimum in monsoon throughout the study period was observed in all the three sites. This monsoonal minimum was mainly attributed to the heavy runoff, which is in accordance with the results of Jagadesan and Ayyakkannu (1992) in Colerron estuary. General trend observed in the present study was positive correlation of free carbondioxide with temperature and salinity and negative correlation with dissolved oxygen, phosphates and pH. Synudheen (2004) have also made similar observation in Shendurni River.

Hydrogen ion concentration did not differ notably between three sites, and remained slightly alkaline throughout the study with minor fluctuation except during monsoon. Seasonal variation between seasons was observed with maximum values during monsoon. Studies carried out in Nethrapur- Gurupur estuary by Gupta et al., (1980) and Bhat and Gupta (1980) indicated that low pH prevailed during premonsoon season, which also agrees with the present observation. Contrary to this pattern a high pH concentration was observed during 2005-06 in January in site I. Altaff (2006) have observed the similar hike in pH in Dakshina Kannada while studying the impact of Tsunami on physico chemical parameters and meiofaunal. He stated this was due to the mixing up organic compounds.

The salinity gradient depends upon the relative balance factors like run off waters from the land, rainfall and evaporation. In the present study wide fluctuation in salinity was noticed with maximum in premonsoon and minimum in monsoon due to monsoonal activity. The two peaks noted during the investigation coincided with the north-east monsoon and south-west monsoon. This may be due to the runoff from the land which resulted in addition of nutrients to the estuary. Singbel (1973); Srinivasan and Raghunathan (1978); Nagarajan and Gupta (1983) and Kondala (1984) during their studies on variation of physicochemical factors of south-west coasts also concluded that fluctuation in salinity structure occurred due to increased fresh water inflow caused by rain in the catchments.

In all the three sites dissolved oxygen showed inverse relationship with temperatures, and free carbondioxide and positive correlation to phosphates and pH. The significant inverse relationship observed between phosphates and salinity throughout the study suggests that apart from the estuarine water, terrestrial run off could be a major source of phosphate to these estuaries. Chandran and Ramamoorthi (1984a) from Vellar estuary, Rajendran (2000) from Imalia and Synudheen (2004) from Trivandrum observed a comparable trend while studying the hydrobiological factors of those estuaries. Free carbondioxide in water was often inversely proportional to dissolved oxygen, which was noticed also by Ajith kumar and Mittal (1993) while studying the water chemistry of Sunderbans

Three distinct types of organisms were found in this ecosystem namely the exclusive mangrove residents, the marine species and fresh water species the last two being frequent visitors to ecosystem.

In the present study, faunal diversity included a total of 394 species, which comprised 43 species of zooplanktons, 5 species of prawns, 14 species of crabs, 34 species of molluscs, 64 species of fishes, 142 species of insects and 82 species of birds. Many informative observations were made and recorded pertaining to the faunal associates of mangrove systems in Kerala with special reference to north Kerala by Radhakrishnan et al., (2006). They recorded the presence of altogether 489 species of fauna comprising 11 species of Hymenopterans 23 species of Odonates, 33 species of Lepidopterans, 21 species of molluscans, 25 species of crustaceans (crabs and prawns), 122 species of fishes and 196 species of birds. The 384 species recovered during the present study from two wetlands compares favourably with survey conducted by Radhakrishnan et al., (2006) which covered 13 estuaries of North Kerala including our study sites.

Of the 43 species of zooplanktons recorded during the present study, 42 species were collected from site I, 26 species from site II and 27 species from site III. It was observed that site I had maximum diversity followed by site III and minimum at site II. Kalidasan (1991) recorded ninety species of zooplankton from Muthupet mangroves. In the present study Copepods (Calanoids and Cyclopoids) were the dominant groups in all the three sites and variation in zooplankton biomass followed a bimodal distribution (except *T. philetaerus*) with peaks during premonsoon and post monsoon. Madhupratap (1978); Balakrishnan et al., (1984); Kumar (1993) have also reported the dominance of Copepods in the Parangipettai estuary and Kadinamkulam back water, which they explained may be due to the plentiful food availability as well as due to their continuous breeding and high reproductive capacity. *T. philetaerus* was abundant during the monsoon season in all the three sites. This species also showed significant positive correlation to dissolved oxygen and phosphates which was at maximum during monsoon. Occurrence of *T. philetaerus* during monsoon agrees with the observation made by Naomi et al., (2005). This can be attributed to higher fresh water influx during monsoon resulting in reduced salinity. Seasonal variation was observed among zooplankton with least production during monsoon and reduced salinity in a mangrove fringed lagoon of south west coast (Goswami and Selvakumar, 1977; Nair 1980a, b; Goswami, 1982; Arunachalam et al., 1982; Nair et al., 1983 and Bhat and Gupta, 1983; Sasi et al., 1999 and Venkitaraman and Das, 2001) and pre monsoon period was observed to be highly productive (Banargee and Choudhury, 1966;Haridas et al., 1973; Pillai et al., 1975; Prasad, 2003). Swar and Fernando, (1980) and Balakrishnan et al., (1984) opined that although most zooplankton species survive under a wide range of environmental conditions their growth and density depend on a number of physical, chemical and biological factors. From the present study it was observed that abiotic factors such as temperature, pH, nutrients and salinity may be related to abundance and occurrence of zooplankton. All species showed positive correlation with temperature, dissolved oxygen, phosphates, pH and salinity. Hutchinson (1967) cited numerous studies which indicated that temperature regulated the birth rate and population characteristics of zooplanktons. Positive correlation of dissolved oxygen, pH and phosphates and zooplanktons was reported by Santhanam and Perumal (2003) and Synudheen (2004) while studying the seasonal variation of zooplanktons in the Parangipettai and Shendurni River respectively. Salinity was observed to be an important parameter regulating the spatial and temporal variation of zooplankton biomass as indicated by Banargee and Choudhury (1966); Sarkar et al., (1986) and Eswari and Remani (2004). In the present study, during the low salinity period the diversity values were lowest. High diversity recorded in the present study during early pre monsoon and post monsoon was in conformity with the studies made in the estuarine areas of Mandovi-Zuari (Goswami, 1982), coastal waters of Trivandrum (Haridas et al., 1980), Pichavaram mangroves (Karuppuswamy and Perumal, 2000).

In the current study 5 species of prawns were observed. Of which all five were collected from site I and III and 2 from site II. Ravindranath (1978) had collected more numbers of eulittoral Palaemonid shrimps (9 species) from Vishakapatnam coast and George (1977) five species from Goa. Kalidasan (1991) reported five prawn species from Muthupet mangroves. Seasonal variation in prawn species richness and abundance in the present study was similar to zooplanktons and was maximum during premonsoon and after a decline in monsoon again increased during post monsoon. Contradictory to the present observation, Achuthankutty (1988) while studying the nursery life of *Metapenaeus dobsoni* observed post monsoon as the active breeding period and salinity did not seem to play a decisive role in immigration and growth.

Data obtained during this study indicated a significant relation between abundance of prawns and four environmental factors viz. temperature, dissolved oxygen, phosphate, pH and salinity. According to Kneib (1987) estuarine distribution of prawns appeared to follow the salinity displacement, the animals being found at river stations during summer and autumn when saline encroachment of the estuary was greater suggesting that reproduction does not take place in fresh water.

The present study revealed the presence of total 34 species of molluscs of which 33 species were recorded from site I, 10 species from site II and 8 species from site III. The high species richness in site I indicates that the estuarine mouth provides the best conditions for the survival ad reproduction of molluscs. Survey conducted by Mitra and Dey (1992) reported that India harbours approximately 3,271 species of molluscs. On the other hand, a checklist of molluscs prepared by Rao (1985) of Indian estuaries includes 245 species. According to him molluscs play a significant role in maintaining the steady state of the mangrove ecosystem and enhance its biological potentiality. Kalidasan (1991) and Kathiresan and David (1998) recorded eighteen species of molluscs from Muthupet mangroves and eleven species from Australian mangroves respectively, which compares favourably with the species richness of molluscs obtained in the present study.

Total 14 species of crabs were collected – 13 species from site I, 4 from site II and 6 from site III. Reports are available on ten species of mangrove crabs collected from Sunder bans (Ajithkumar,1975) and a total of 38 Brachyuran species recorded from Pichavaram and 8 species from Vellar estuary (Ajmal et al.,2005). Fifty species of Brachyuran crabs under 31 genera have been reported from mangrove habitats of India (Dev and Das, 2000). Eighteen species of Brachyuran crabs under nine genera and four families are identified from

Sunderbans mangrove ecosystems (Chakraborty and Choudhury, 1992). Survey conducted by Radhakrishnan et al., (2006) at various mangrove areas of Kerala observed twenty species of crabs which includes few similar species like *C. feriatus, C.lucifera, P.pelagicus, S.serrata, D.intermedia, D.myctiroides Ocypode* species and *U.lactea* that were collected in the present study.

Species richness of crabs and molluscs was highest during post monsoon and premonsoon seasons respectively. The low density encountered during monsoon may be due to monsoonal flood, low salinity and submerged condition of mud banks. This pattern was also observed by Chandran et al., (1982) while studying the ecology of macro benthos of Vellar estuary. Prabha (1994) while studying the ecology of benthic fauna of Colerron estuary reported that the eroded bank of the estuary during rainy season was one of the major factors influencing the existence of benthic fauna. Pedro et al., (2001); Harkantra and Rodrigues (2003) and Marakala et al., (2005) pointed out that salinity appeared to have some effect on the benthic faunal distribution with low species diversity in monsoon. Mahoney and Livingston (1982) stated that the mechanisms behind the seasonal fluctuations of the benthic organisms revealed that more than one environmental variable may be responsible for the seasonal variation of benthic organisms. In the present observation high population density was associated with silty sand and sand silt clay at site I and II. Comparative low population density at site III may be associated with clayey sand and absence of mud banks which was supported by the observation made by Jagadesan and Ayyakkannu (1992) along the west coast and Radhakrishnan et al., (2006) in the faunal survey of mangrove ecosystem of North Kerala. Sunilkumar (2002) suggested that the varying abundance of molluscs among mangrove sites may be correlated with the difference in texture and nature of the mangrove substratum. Reports by Chakraborty (1984) reveals that as the temperature within the burrow of crab does not fluctuate in relation to the temperature of air and soil, temperature is not supposed to play a great role. The dominance of *T. telescopium* in the present study compares favourably with the studies of Singh and Choudhury (1978) from Sunderbans, who suggests the dominance of *L. melanostoma* and *T. telescopium.* In the present study *P. pelagicus* which was observed only in monsoon season showed significant negative correlation with temperatures, carbondioxide and salinity. All other species showed positive correlation.

James et al., (1979) observed that the size and density of the crab population depend on habitat. Choudhury et al., (1984) noted that seasonal oscillation of different hydrological parameters, different degree of tidal amplitude and rate of siltation render complex environment for macrobenthic fauna of mangrove ecosystem. High species abundance noted in the present study may be due to the large scale ingress of nutrient rich waters from the surroundings in site I which is closer to the bar mouth. The closeness of this site to the bar mouth had made this region into a highly suitable environment for the recruitment and colonization of plankton population. This observation is supported by Kumar (1995) who observed a progressive decrease in the species composition of benthos from the bar mouth to the interior stations in mangrove ecosystems of Cochin backwaters. The crustacean and molluscan group, predominantly marine forms were dominant in bar mouth due to prevalent environment of the area, which acts as a passage towards the nursery grounds (Ambrose, 1986 and Marakala et al., 2005).

In the present study 142 species of insects were collected from all the three study sites and compares favourably with studies carried out in various mangrove ecosystems in India. Earlier studies on insect fauna of mangroves mentioned only the presence of biting midges, ants, mosquitoes and fireflies (Walsh, 1974; Chapman, 1977). Murphy (1990) reported about 100 species of insect herbivores from Singapore and Veenakumari et al., (1997) reported almost double number of insect species from mangals of Andamans. Over 72 species of insects belonging to seven orders have been listed from Sunderbans (Choudhuri and Choudhury, 1994). Radhakrishnan and Rao (1987) documented 450 insects species associated with mangrove ecosystem of Kerala. Ken-ichi-Abe (1988) reported that three insect orders namely Hymenoptera, Diptera and Psocoptera composed the arboreal fauna in mangrove ecosystem of Halmahara but in our study seven orders of insects, namely – Orthoptera, Hemiptera, Coleoptera, Odonata, Neuroptera, Diptera, Hymenoptera and Lepidoptera were collected. Hymenopterans ranked first (43 species) followed by Odonates (34 species) in species diversity in the present study. This abundance of hymenopterans was mainly contributed by Formicidae. Ken (1980) also found the Hymenopterans to be the richest order and the abundance of Formicidae were also marked while studying the arboreal arthropod community of mangrove ecosystem of Indonesia. He stated that Formicidae with its specialized adaptation to environment can occupy considerable part in mangrove arboreal fauna. Deiva (1998) observed 113 species of insects from Muthupet mangroves.

Three species of mosquitoes are reported from Sunderbans (Naskar and Guhabakshi, 1987), Pichavaram (Thangam and Kathiresan, 1993), and Muthupet (Deiva, 1998) while in the present study five species were collected.

Coleopterans comprised predominantly of insect pests infesting the floral components. Some weevils have been observed from mangrove seed capsules. Numerous studies on the insect borers was conducted by Das et al., (1982, 1988) and Dev et al., (1987), they found that majority of coleopteran species are pests. In the present study also the presence of 23 species of Chrysomelids and 5 species of Cerambycids indicate that most of them may be pests.

In the present observation insects were mostly found during the post monsoon season. Radhakrishnan et al., (2006) also have made similar observation while working in insect fauna of mangroves of North Kerala. The lush- green phase of growth, followed by the flowering phase of mangrove floras may have contributed to this abundance. The presence of 19 species of lepidopterans and 7 species of bees collected during the flowering season in the present study is a pointer to the importance of these insects as pollinators of mangroves.

Among the 64 species of fishes observed and collected, 52 species was recorded from site I, 29 species from site II and 41 species from site III. Mangroves of Australia provide favourite fish habitats for about 197 fish species (Anon, 1997). Cecilia (1996) observed 73 species of fish from Muthupet mangroves and Kathiresan and David (1998) recorded 24 species of fishes from Australian mangroves. About 150 species of fishes have been reported from Chilka Lake (Jones and Sujansingani, 1951) and 27 species from Ayiramthengu mangroves (Jisha et al., 2004). In the present study the ichthyofaunal abundance can be correlated to species richness observed in crustacean fauna. Reports by Rajagopalan et al.,(1986); Robertson and Duke, (1987); Blaber and Milton, (1990); Morton, (1990); White field, (1993) and Laedsguard and Johnson, (1995) reveals that mangrove areas serve as feeding, breeding and nursery grounds for many commercially important shell and fin fishes, in addition to providing shelter for the juvenile stages of these groups. Moreover, mangrove vegetation offers a less disturbed habitat for fishes (Sheridan, 1992). A single representative of unidentified stone fish was collected from site III. Presence of reef associated fish (Stone fish) in estuaries is reported by Kumaraguru and Rajkumar, (2004) from Vellar estuary. The occurrence of reef fishes in Vellar estuary is presumably attributed to the presence of a coral reef in Parangipettai coastal waters. But the presence of this reef fish in site III is hard to explain as there are no coral reefs in the nearby coastal waters.

Comparative study of three sites showed maximum ichthyofaunal diversity at site I, which may be due to high organic productivity, detritus and stagnant nature of water body besides the protection provided by the mangrove vegetation. The low species diversity at site II may be due to anthropogenic interference, as human habitations abound this area. The riverine stretch (site III) had high biodiversity and low population density. This areas are the transit way for the both river and sea species. In the present study maximum ichthyofaunal diversity was observed during premonsoon, late monsoon to early post monsoon seasons. Chandrasekaran and Natarajan (1993) also came across the same trend in Pichavaram mangroves; they observed maximum population abundance during summer.

82 species of birds which included both migrants and residents were observed during the study period. 79 species was recorded at site I, 36 species at site II and 26 species at site III. The 82 species identified from the Kadalundy estuary and mangrove areas (site I and II) during the present study highlights the suitability of this area as a habitat for avifauna. But Kurup (1991) and Vijayakumar (2006) had observed only 42 species of birds (shore birds and sea birds) from Kadalundy. Balakrishnan et al., (2002) in their study had reported 29 species of wintering birds from Kadalundy estuary. The mangroves and the associated wetlands provide good foraging ground for many species of migratory shore birds, gulls, terns and other resident fowls. According to Radhakrishnan et al., (2006), 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.

Presence of high diversity of insects, including the pollinators during the present study warrants a detailed study of the role these insects play in the propagation of mangroves. The high faunal species richness observed in the present study in the Kadalundy estuary and mangrove areas (site I and II) when compared to the Nallalam mangroves gives us an idea about the uniqueness of the Kadalundy wetland. Elaborate studies on the faunal diversity of these mangrove ecosystems and their intricate relationship is needed to get a vivid picture of these ecosystems and will contribute to devising appropriate conservation methods for protecting these habitats.

CONCLUSION

Araty Sasikumar "Faunal diversity of mangrove ecosystems of Kadalundi and Nalallam, North Kerala, India" Thesis. Department of Zoology, University of Calicut, 2009

CONCLUSION

CONCLUSION

Brackish water environment in general and mangrove areas in particular have been the topic of interest for the biologists mainly because of their high productivity and rich biodiversity. The mangrove marshes are among the most productive ecosystems of the world. Their average organic matter production is approximately 20g/m^3/day (Kathiresan, 1998), which is seventy times more than that of tropical oceanic waters. Diverse environmental settings of aquatic habitats in the coastal zone have made these aquatic habitats the centers of higher productivity of biodiversity resources.

The three study sites undergo important hydrobiological changes during monsoon months, similar to other estuaries. The climate over here 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 (premonsoon). It is followed by the south west monsoon that continues till the middle of October. The north east monsoon starts during mid October and may that last up to the end of February. As per the data obtained on physico-chemical parameters, it can be concluded that mangrove wet lands have direct relationship to the factors of topographic diversity, variations of river discharges and the degree or amount of fresh water flow, sediment load.

Throughout the study period seasonal variation in atmospheric temperature, surface water temperature, dipped water temperature, free carbondioxide and salinity was observed. These parameters were maximum in premonsoon season and decreased during monsoon in all the three sites. Negative correlation was observed between dissolved oxygen, phosphates and pH. This may be due to the increased fresh water inflow during rainy season and lesser decomposition rate due to the lower temperature. A positive correlation was observed between temperature, free carbondioxide and salinity and inversely correlated with dissolved oxygen, phosphates and pH during 2002-04 in all the three sites. During 2004-06, pH showed positive correlation with temperature, free carbondioxide and salinity in site I and II. Similar correlation was seen in site III during 2004-05

Survey and study of the mangroves and their faunal associates in the three study sites based on the collections/ observations of fauna revealed the presence of altogether 384 species comprising of both invertebrates and vertebrates. The 238 species of invertebrates comprised 62 species of crustaceans (consisting of zooplanktons, prawns and crabs), 34 species of molluscs and 142 species of insects. Among the vertebrate fauna 64 species of fishes and 82 species of birds were observed and identified.

Correlation analysis of zooplanktons with physico-chemical parameters from all the three sites showed that during 2004-05, Calanoids, Cyclopoids, Harpacticoids, Decapods and Chetognaths showed positive correlation with temperatures, pH and salinity, while during 2005-06 they showed negative correlation with temperatures, pH and salinity, but were positively correlated with dissolved oxygen and phosphates. *T. philetaerus* showed positive correlation with dissolved oxygen and phosphates and negative correlation with temperatures, pH and salinity throughout the study period. Among zooplanktons

Acartia major was the dominant species throughout the study in all the three sites.

Faunal analyses reveal that among the three sites studied, the mangrove wetlands of Kadalundi (site I), owing to their richness of vegetation stands, harboured richer assemblage of faunal associates. Studies show that Site I is used as the homing environment by a wide variety of animals, both invertebrates and vertebrates as it is comparatively less influenced by anthropogenic pressures. Comparatively less species richness in site II, owed to the increasing human pressure for domestic needs and development- which has virtually destroyed large areas of virgin mangroves. Reclamation of mangroves for housing, agriculture, cattle grazing, sewage discharge also caused a negative impact in this area.

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 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, terns and other resident fowls.

In general, it was observed that the population density of aquatic forms was at maximum during premonsoon months followed by post monsoon season. The lowest was recorded in the monsoon months, which is characterized by heavy rainfall, greater riverine discharge and greater suspended particulate matter, which make the conditions unfavourable for faunal growth and density. This trend is similar to the variations shown by physico-chemical parameters. It can be concluded that the species richness observed in the study sites are not due to influence of any single factor never, but a result of interaction of many factors. The plant and animal comprising the mangrove ecosystem form the golden asset of coastal marine resources. It is generally recognized that mangrove areas form the feeding and nursery grounds for the juveniles of aquatic forms. However, mangrove areas are ecologically fragile due to constantly fluctuating dynamics of environmental factors besides the pollutants from seaward and landward areas. Hence there is an urgent need to conserve mangrove ecosystems in order to materialize their rational exploitation with reference to their aquatic resources.

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