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Review on Biodiversity of Marine and Mangrove fungi

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Introduction

Biological diversity refers the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystem and ecological complexes of which they are part. Biodiversity encompasses all life forms, ecosystems and ecological processes and acknowledges the hierarchy at genetic, taxon and ecosystem level. The essential ingredients of biodiversity are phenotypic flexibility genetic variation within populations and ecotypic variations (Ananthakrishnan, 1997). Microbial biodiversity can be viewed from a variety of perspectives, including physiological diversity, interaspecific genetic diversity and phylogenetic diversity of species and higher taxa (Delong, 1997). Microbial diversity represents the largest untapped reservoir of biodiversity for potential discovery of new biotechnological products, including new pharmaceuticals, new enzymes, new special chemicals or new organisms that carryout novel process (Jensen and Fenical, 1994).

Biodiversity of Fungi

Fungi are eukaryotic, spore producing achlorophyllous, heterotropic organisms with absorptive nutrition that generally reproduce sexually and asexually and whose usually filamentous branched somatic structure known as "Hyphae", typically surrounded by cell wall. They secrete digestive enzymes outside their bodies and absorb the nutrients. They also produce valuable source, chemicals, antibiotics and enzymes.

Biodiversity of fungi is an important aspect to be dealt with utmost scientific accuracy and accountability. One third of fungal diversity of the globe exists in India. Out of 1.5 million of fungi, only 50% are identified and remaining 50% need to be identified. Unfortunately around 5 –10% of these fungi alone can be cultured artificially. The variety and galaxy of fungi and their natural beauty occupy prime place in the biological world and India has been the cradle for such fungi. Only a fraction of total fungal wealth has been subjected for scientific scrutiny and mycologists have to explore the unexplored and hidden wealth (Manoharachary *et al*., 2005)

Marine and Mangrove habitats

Marine and estuarine habitats are oceans and ocean –associated smaller bodies of water that contain salt or brackish water, including river mouths, sounds, lagoon, tidal creeks, salinas, etangs and the like. Mangrove vegetation or "Mangle" is the tropical counter part of the tidal salt –marshes of temperate regions. In the sub- tropics, both types of communities may mingle. The "Mangle" is composed of the wide variety of shoreline trees and bushes belonging to numerous, often unrelated plant families and share the common ability to grown in estuarine and coastal environments. They are open systems with respect to energy and matter and thus couple upland terrestrial and coastal estuarine ecosystem (Lugo and Snedaker, 1974).

India has a vast coastline of about 5,700 km divided into east and west coasts. Mangroves as one of the coastal wetland ecosystems offer an ideal environment for fish farming. Several species of flora and fauna, native to mangrove environment, depend on the stability of this environment (Untawale, 1987). The biomass produced in mangrove is enormous and it is recycled by various organisms including wood borers, fungi and bacteria. This recycling of nutrients is essential for the sustenance and maintenance of this environment.

Indian peninsula comprises about 7000 sq km of mangroves, out of which 70.18 only (12%) are distributed in the East coast, Andaman – Nicobar Islands and West coast respectively (Krishnamurthy *et al*., 1987). Mangrove forests of India are dispersed in tropical as well as subtropical conditions. Unique conditions prevail in these habitats that are responsible for detritus generation, accumulation, processing and turnover. During heavy rainfall which results in flushing freshwater and sediments to mangrove habitats and leads to decline in salinity to zero. During post –monsoon until January, salinity increases up to about 50% (Sridhar and Kaveriappa, 1988). Such conditions are favorable for fresh water fungi to exploit mangrove substrata. Live and dead twigs of mangrove canopy harbour terrestrial fungi and addition of such substrata into mangrove waters in monsoon (Wafar *et al*., 1997) results in domination of terrestrial fungi for several months (Maria and Sridhar, 2003). Recent study of west coast mangroves revealed that nearly one –third of wood – inhabiting fungi belong to terrestrial group (Maria and Sridhar, 2003). Endophytic fungi of mangrove leaves, stem and roots consists of more terrestrial than marine fungi (Ananda and Sridhar, 2002; Kumaresan and Suryanarayanan, 2001). In mangrove habitats, atleast up to six months under low salinity, freshwater and terrestrial fungi are involved in litter conditioning. In summer, increased salinity supports the activity of mainly marine fungi on detritus. Core group fungi (frequency $\geq$ 10%) on woody debris between west and east coast of India largely due to difference in diversity of mangrove plant species (Maria and Sridhar, 2002; Sarma and Hyde, 2001).

Mangroves are open systems with respect to both energy and matter and can be considered “interface” ecosystems coupling upland terrestrial and coastal estuarine ecosystems. (Lugo and Snedaker, 1974). While terrestrial fungi and lichens occupy the aerial parts of mangrove plants, the marine fungi occur at lower parts where their trunks and roots are permanently or intermittently submerged in water. At the high tide mark there will be an interface and an overlap of marine and terrestrial fungi that occur (Kohlmeyer, 1969a; Kohlmeyer and Kohlmeyer, 1979). Mangrove forests generate considerable amount of detritus such as leaf litter, woody debris and infloresence (Wafar *et al*., 1997) and hence constitute an ideal habitat for many detritus – dependant fauna and microbes.

Diversity of Marine fungi and Mangrove fungi

Marine fungi have the ability to grow at certain seawater concentrations (Johnson and Sparrow, 1961; Tubaki, 1969). It has been shown that marine fungi cannot be defined strictly on a physiological basis where as, a broad ecological definition names that the marine fungi of obligate types are those that grow and sporulate exclusively in a marine and estuarine habitat. Facultative forms are those from fresh water or terrestrial milieus able to grow in the marine environment (Kohlmeyer, 1974).

While viewing into the role of fungi in the marine ecosystem marine fungi are the important intermediaries of energy flow from detritus to higher tropic levels in the marine ecosystem. They require seawater for the completion of their life cycle. About 50,000 fungal species are known from terrestrial habitats (Ainsworth, 1968), but in contrast, less than 500 species have been described from oceans and estuaries, which cover a much larger area, namely 3 quarters of the world. The higher filamentous marine fungi include, 209 species, the marine occurring yeasts comprise 177 species and the cover marine fungi comprise probably less than 100 species. The oceans, compared to the landmasses, provide stable environments with little change in temperatures and salinities, organic substrates concentrated mostly along the shores, where they provide nutrients for the occurrence of fungi. The open sea is a fungal desert where only yeasts or lower fungi may be found attached to planktonic organisms or pelagic animals. The higher marine fungi occur as parasites on plants and animals or as symbionts in marine lichens and algae.

The higher marine mycota or manglicolous fungi which occur on submerged parts of mangroves include 42 species, and are the fourth largest ecological group after the wood, salt-marsh, and algae – inhabiting species. These mangrove fungi are almost exclusively saprobes and belong to the family Ascomycetes, Deuteromycetes, and Basidiomycetes. The majority of manglicolous marine fungi are omnivorous and occur mostly on dead cellulosic substrates all around the tropics (Kohlmeyer and Kohlmeyer, 1979). According to Chowdhery (1975) the mangrove isolates or the marine fungi have higher osmotic optima as compared to their fertile soil counter parts. In mangrove swamps, the microbial life has to withstand high salinity and fungi found in this habitat show a high degree of osmotic tolerance and increased salinity optima.

Recent checklist of mangrove fungi revealed that a total of 625 fungi exist at global scale represented by 278 Ascomycetes, 277 Anamorphic taxa, 30 Basidiomycetes and 14 Oomycetes (Schmidt and Shearer, 2003). The global and Indian scenario on mangroves provides unique opportunities for mycologists to explore fungal diversity and exploit their ecological, medical and industrial potential.

Role of Fungi in Aquatic ecosystem

Fungi are known to play vital roles either as decomposers, symbionts of plants and animals and also parasites on plants in different ecosystem. Out of 1.5 million species of fungi, many remain un-described. Fungi grow in every conceivable habitat/ substrate having organic carbon. Decomposition of plant remains is an essential process accomplished by the fungi in nature, which balance the continuous requirements of raw material for green plant. Decomposition of organic matter in river, marine and estuarine waters is brought about by diverse aquatic biota namely, bacteria, fungi, nematodes and worms. Aquatic fungi have been reported to improve the palatability and nutrient content of plant and animal remains. The survival and success of fungi as decomposers are largely depend on their ability to adapt to their environment immediately surrounding the substratum and to provide viable reproductive units. Along with nature of substrate, everchanging factors like light, temperature, oxygen and hydrogen ion concentration act either singly or in concert to influence substrate colonization, growth and reproduction of a fungus.

In the natural environment, substrate degradation is achieved by association of succession of taxonomically unrelated fungi and other organisms adapted to or tolerant to the special environment conditions associated with the fluid medium. Marine fungi play an important role in nutrient regeneration cycles as decomposers of dead and decaying organic matter.

Mangroves being detritus- based considerable fungal population are involved in detritus processing and hence special attention is necessary to assess mycoflora. Export of organic materials from mangrove to the offshore is an important function (Lugo and Snedaker, 1974). Mangrove leaves, twigs and seagrasses fallen into water are colonized by bacteria and fungi. The fine particles of such detritus which are further colonized by microorganisms are utilized by detritus- feeding zooplankton and small animals (Odum *et al.,* 1979).

Furthermore, Mangroves are one of the richest and most productive of habitats and litter from mangrove trees form the base of food chains in tropical estuarine environments. It is to be highly noted that mangrove vegetation contributes to the primary production in the aquatic environment in the form of leaf and litter fall. Decomposition of this organic material by bacteria and fungi results in protein – enriched fragments of detritus.

Fungal Biotechnology

Fungal biotechnology has become an integral part of human welfare. Nature represents a formidable pool of bioactive compounds and is more than ever a strategic source for new and successful commercial product. Among the microorganisms, fungi are well recognized to produce a wide variety of most valuable pharmaceutical chemicals, agrochemicals and industrial products. Recent advances made in genomics, proteomics and combinatorial chemistry show that nature maintains compounds that are the essence of bioactivity, within the host and environment. So the major challenging task is to explore the unexplored fungal wealth in our country and reveal their potential applications.

The screening of marine fungi for novel bioactive compounds has yielded several novel metabolites, some of which are being commercially developed for medicinal or agricultural use. Sadly the data generated by pharmaceutical companies in screening for bioactive compounds if often ‘lost’ to science due to the need for industrial secrecy. Fungal enzymes are widely used in industry and, many vitamins and food supplements rely on fermentation processes using terrestrial fungi. Due to their slow growth rates it is unlikely that marine fungi will replace their faster – growing terrestrial counterparts in this respect.

Many important industrial products are now produced from fungi using fermentation technology. A wide range of enzymes are excreted by fungi and play an important role in the breakdown of organic materials and many of these enzymes are now produced commercially. Most of these enzymes are used in food processing. Fungi are good candidate for employing them in degrading refractory substrates, cellulose, lignin, chitin, keratin and other substrates. Fungi like *Aspergillus niger* and *A. oryzae* are regarded as safe by the food and drug administration.

Microbial cells produce a variety of enzymes and help in microbial growth and respiration including other cellular activities. At times, these enzymes may themselves become fermentation products, so that one of them is specifically interested in obtaining high level of the enzymes (Bell *et al*., 1972). Qualitative screening of degrading enzymes in marine fungi was reported by Rohrmann and Molitoris (1992).

The use of enzymes in food preservation and processing predates modern civilization. Fermentation of common substrates such as fruits, vegetables, meat and milk provide a diverse array of food in the human diet. Beer, wine, pickles, sausage, salami, yogurts, cheese and buttermilk are all fermented products. Irrespective of their origin, these fermented food products are, in fact, result of the enzymatic modification of constituents in the substrate. The use of enzymes in food industry also involves a range of effects including the production of food quality attributes such as flavors and fragrances and control of colour, texture, and appearance besides affecting their nutritive value.

Molecular techniques and Phylogeny

The study of systamatics and population biology of filamentous fungi entered a new era with the introduction of molecular biological techniques. This new approach to fungal systematics has been accelerated by the relative simplicity of these techniques and the use of particular regions of the relatively small fungal genome. Fungal molecular systematics has increased our understanding of taxonomic groupings and evolutionary histories within different groups of fungi. The evolution among the polyphyletic assemblage of organisms once considered to be fungi has been well documented with the advances of molecular techniques (Bruns *et al*., 1991,1992; Barr, 1992; Berbee and Taylor, 1993, 1995). Molecular techniques used in fungal systematics can be divided into two main areas such as Protein and DNA analysis.

Advances in molecular techniques have made a large impact in many areas of mycology, one of which is fungal phylogeny and this includes the lower fungi, Chytridiomycetes to those of Ascomycetes and Basidiomycetes. Other studies have increased our knowledge of the taxonomy of certain fungi, which have been previously assessed only by morphological characters (Nishida *et al*., 1995). DNA sequences have been used both as phylogentic characters and as a measure of dating the evolution of different groups of fungi, filling the gaps of information from the lack of fossil records (Berbee and Taylor, 1993,1995). More intensive work must be emphasized in molecular marine mycology to solve the phylogenetic relationships among several genera, which were assessed earlier by morphological and ultrastructural work.

Advances in molecular technology have enabled rapid strides to be taken in the area of amplication and detection technologies of important fungal pathogens, detection of fungi in the natural environment as well as geographical evolution of specific strains of fungi (Goodwin and Annis, 1991; Levesque *et al*., 1994; Jungeh Ulsing and Tudzynski, 1997; Sreenivasaprasad *et al*., 1996; White, 1996; Jeng *et al*., 1997; Maurer *et al*., 1997; Pei *et al*., 1997; Liew *et al*., 1998). With the large number of DNA sequence data within sequence database centers, the possibility of designing species or generic specific primers for fungi is relatively easy. This will greatly increase the detection of fungi from the natural environment but will depend on the time and amount of funding available to the molecular mycologist.

Biodiversity of marine and mangrove fungi

Most early studies on fungi colonizing mangroves were taxonomic and confined mainly to cataloguing fungi and describing new taxa collected in a given area (Cribb and Cribb, 1955; Kohlmeyer and Kohlmeyer, 1964 – 1969, 1971, 1977; Kohlmeyer, 1966, 1969a, 1981, 1984, 1985; Kohlmeyer and Schatz, 1985). Until recently, there have been few ecological studies on manglicolous fungi. Recent studies on inertial mangrove fungi have provided information on (a) frequency of occurrence (b) vertical zonation, (c) host and substratum specificity, (d) succession, and (e) seasonal occurrence (Aleem, 1980; Jones *et al*., 1988; Hyde, 1988a, 1989c, 1990b, 1991; Leong *et al*., 1991; Poonyth *et al*., 1999). Of these, considerable effort has been spent investigating the frequency of occurrence of manglicolous fungi (Jones and Tan, 1987; Borse, 1988; Hyde, 1988a,b, 1989a,b,c; Hyde and Jones, 1988; Jones *et al*., 1988; Jones and Kuthubutheen, 1989; Tan *et al*., 1989; Tan and Leong, 1990,1992).

Early studies on marine fungi on mangroves have focused on taxonomy of marine fungi including descriptions of new species and new genera, lists of fungi and surveys. This includes the marine fungi occurring in mangrove environments. Excellent reviews and vast amounts of information on marine fungi have appeared in several texts. (Johnson and Sparrow, 1961; Jones, 1976; Moss, 1986; Hyde and Lee, 1995; Jones, 1995; Jones and Alias, 1996). For several accounts on various aspects of marine fungi the following works, among others, are referable (Chinnaraj, 1993a; Jones and Tan, 1987; Hyde and Jones, 1988; Hyde, 1990a; Hyde *et al*., 1990; Ravikumar, 1991; Leong *et al*., 1991; Kohlmeyer and Kohlmeyer, 1979; and Kohlmeyer *et al*., 1995). Ecological studies on manglicolous fungi are relatively recent i.e. from late 1980s onwards. A wealth of information is now available on different ecological aspects of fungi in mangroves including frequency of occurrence, vertical distribution, substrate preference, succession, seasonal occurrence and host specificity. However these are mainly from South East Asia (Hyde and Lee, 1995; Jones and Alias, 1996).

There are umpteen literatures on the ecology and taxonomy of soil fungi Most of the reports relate to the study of fungal flora from cultivated agricultural soils, uncultivated soil, pasturelands and forest soils. However, little is known about the microbial ecology of mangrove swamps. During the past several years, considerable work has been done on the taxonomy and ecology of mangrove swamp fungi in India (Padhye *et al.*, 1967; Pawar, *et al*., 1963; 1965 and Rai and Tewari, 1963).

Earliest studies on the ecology of mangroves fungi Kohlmeyer (1969a) encountered 3 common species of marine fungi in the mangrove habitat, namely *Lulworthia* spp (20% of all collections) *Leptosphaeria australiensis* (15%) and *Phoma* species (10%). 100 Mangrove species; only 8 have been examined for the occurrence of marine fungi and the latest Island research was conducted in Bermuda and collected 15 marine Ascomycetes, 1 Basidiomycetes, and 6 Deuteromycetes (Kohlmeyer and Kohlmeyer, 1977). Aleem (1980) reported that the Ascomycetes; *Halosphaeria viscidula*, *Rosellinia* sp and *Torpedospora radiata* were frequent on mangroves in sierra Leone and also found that the Mitosporic taxa. *Cirrenalia macrocephala*, *C. pygmea*, *C. tropicalis*, *Periconia* and *Zalerion* spp were abundant on mangrove wood. Kohlmeyar (1984) also reported that *L. australiensis* was a common species of mangroves. Although mangrove fungi of the West coast of India have been well studied, there have been few studies on the East coast (Bay of Bengal), despite the fact that its mangroves are more extensive compared to the west coast. (Untawale, 1987). Hyde and Jones (1988) observed the some fungi tend to occur configuration at certain levels and also reported that the greater species diversity occurred at the mid – littoral level.

Booth (1971b) observed on occurrence and taxonomy of aquatic fungi in saline habitats. Hyde (1989a) reported that the lignicolous materials were collected from 5 marine locations in Brunei; a rocky head land, a sandy beach, a man – made brackish lake, a healthy mangrove and an oil - polluted mangrove. Higher marine fungi present were identified and their percentage occurrence noted. There were significantly less diversity and number of fungi in the oil-polluted mangrove when compared to the healthy mangrove. Most attention to data has concentrated on assessment of fungal diversity, physiology and biochemistry (Kohlmeyer and Kohlmeyer, 1993). Hyde and Lee (1995) suggested that the diversity of marine fungi is greater in the tropics and attributed this to mangrove tree species richness. Jones *et al.* (1999) recorded all marine fungi from Marine habitats can be designated as micro fungi the "micro habitat predictor " model appear to the applicable in the marine environments.

There have however been no efforts to study the marine fungi on mangroves until recently when systematic studies on manglicolous fungi in India were initiated. A detailed investigation of fungi on mangroves of west coast was made by Patil and Borse (1985a,b) and Chinnaraj (1993a,b). However vast tracts of mangroves on the east coast remained virtually unexplored except for the studies of Ravikumar and Vittal (1996).

Quantitative data on the occurrence of tropical marine fungi have been published by Raghukumar (1973); Koch (1986); Kohlmeyer (1984); Zainal and Jones

(1984, 1986). However all of these reports were on driftwood in the sea, along with driftwood on the mangrove floor or panels belonging to various timbers submerged near jetties.

Marine fungi have been classified into three geographical groups by Kohlmeyer and Kohlmeyer (1979): i) cosmopolitan species; ii) temperate – water species and iii) species from tropical and subtropical waters. Mangrove fungi have been incorporated in biogeographical maps by Jones (1993), Kohlmeyer (1981, 1984), Kohlmeyer and Volkmann – Kohlmeyer (1987) and Volkmann - Kohlmeyer and Kohlmeyer (1993). Based on the distribution in Atlantic Ocean, Indian Ocean, South – East Asia and Pacific Ocean. Hyde and Lee (1995) revised geographical distribution of representative mangrove fungi (*Halosarphaeria fibrosa*, *H. marina*, *Lignincola laevis* and *Lulworthia grandispora*). Geographical and seasonal distribution of *Asteromycetes cruciatus, Stigmoidea marina* and *Varicosporina ramulosa* correlated with their growth patterns under different temperature regimes (Boyd and Kohlmeyer, 1982).

Predominantly mangrove species: the Ascomycetes *Dactylospora haliotrepha, Halorosellinia oceanica, Lignincola leavis, Lulworthia grandispora, Saagaromyces abonnis* and *Verruculina enalia*;the basidiomycete *Halocyphina villosa* and anamorphic fungi *Cirrenalia pygmea* and *Zalerion varium* (Kohlmeyer 1984; Jones and Alias, 1996; Sarma and Hyde, 2001; Abdel-Wahab and El- Sharouney, 2002; Jones and Abdel-Wahab, 2005). Other species are more characteristic of open ocean waters: *Antennospora quadricornuta, A. salina, Periconia prolifica, Torpedospora radiata*, or wood associated with sand: *Corollospora maritima*, *Trichocladium melhae*. Mangrove fungi of the east coast of India have been well studied, there have been few studies on the east coast (Bay of Bengal), despite the fact that its mangroves are more extensive compared to the west coast (Untawale, 1987).

The marine fungi of Hong Kong and Thailand have been studied intensively over the past 15 years, and include not only random collections of drift material, but also the exposure and recovery of bait samples (exposure of bait in Hong Kong (Vrijmoed *et al.*, 1986; Sadaba *et al.*, 1995; Abdel- Wahab, 2000; Thailand: Pilantanapak *et al.*, 2005), collection of drift and attached mangrove samples in Hong Kong (Abdel-Wahab and El-Sharouny, 2002; Jones and Vrijmoed, 2003), Thailand (Hyde *et al.*, 1993; Sakayaroj *et al.*, 2004). Schmidt and Shearer (2004) analysed the geographical distribution data published on lignicolous mangrove fungi, and found that different oceans supported varying numbers. The number of fungi at each site varied: Atlantic Ocean: 12-46 per site (14 sites: mean 25.6); Indian Ocean: 12-64 (14: 42.9) and the Pacific Ocean: 17-87 (16: 44). The Pacific Ocean has the highest recorded number of fungi, again the result of repeated collections over many years: Hyde (1988c) in Brunei; Jones and Kuthubutheen (1989), Alias *et al.* (1995), Tan *et al*. (1989) and Leong *et al.* (1991) in Singapore, and the greater diversity of mangrove tree species in this region. The paucity of marine fungi from the Atlantic has been attributed to low mangrove tree diversity, for example three in Florida mangroves and four in the Bahamas (Jones and Abdel-Wahab, 2005; Jones and Puglisi, 2006). However, more intensive collections yielded 81 species for Florida mangroves from 250 collected samples (previously only 28: Jones and Puglisi, 2006) and 112 for the Bahamas from 600 collected samples, where only 31 had previously been recorded (Jones and Abdel-Wahab, 2005).

Diversity most simply can be expressed as species richness, that is the number of species (Magurran, 1988). However, since richness increase in direct relation to number of individuals, area and variety of habitats sampled. Ecological variation over the temporal and spatial dimensions of the sample may augment diversity because of the increased number of areas, habitats or seasons included. Hyde (1990c) recognized the different in the common species at study sites, a core group of fungi occurring in the mangrove ecosystem. The Majority of the species *Dactylospora haliotrepha*, *Leptosphaeria avicenniae* were also reported from Brunei and other tropical mangroves (Hyde 1989a). Alias *et al*. (1995) reported that more than 60 fungal species can be recorded as common to mangrove ecosystems of the West Indo Pacific region.

Chinnaraj (1993a,b) had earlier reported 63 species of higher marine fungi from the Andaman and Nicobar Islands, which are approximately 1000 km away from the mainland on the East coast. Ravikumar and Vittal (1996) reported 48 species belonging to 37 fungal genera on *Rhizophora apiculate* at Pichavaram.

As diverse vegetation exists in mangroves, it is considered as a major niche of fungal repository. Mangrove fungal diversity is dependent on the age of mangrove, diversity of mangrove plant species and the physicochemical features of mangrove habitat (temperature, salinity and tidal range) (Hyde and Jones, 1988; Jones, 2000). Twenty-eight mangrove tree species yielded 120 higher marine fungi (Hyde, 1990b). Fifty-five mangroves and their associates yielded about 200 higher marine fungi (Jones and Alias, 1996). *Rhizophora apiculata* among the mangrove tree species harboured a maximum of 63 higher marine fungi (Sarma and Vittal, 2000).

Among the different geographical locations; South East Asia has been sampled most thoroughly (Hyde and Lee, 1995; Jones and Alias, 1996). There seem to be no discernible difference between mangrove fungi reported in the subtropics as compared to those found in tropical areas. Among 900 known marine fungi, 358 are recorded from the mangrove ecosystem (Jones and Alias, 1996; Jones and Mitchell, 1996). Out of 54 mangrove tree species and 60 mangrove associate plant species, up to 55 species have been studied for fungi (Jones and Alias, 1996). Studies on mangrove fungi from the Indian Ocean are limited compared to the Atlantic Ocean and Pacific Ocean and South – East Asian region. Although the Indian peninsula possesses about 6700 km^2 of mangroves (Natarajan, 1998) only a few studies dealt with fungal richness and diversity in Gujarat (Borse *et al*., 2000; Patil and Borse, 2001), Maharashtra (Borse, 1988), Karnataka (Ananda and Sridhar, 2003), Tamil Nadu (Ravikumar and Vittal, 1996) and Andra Pradesh (Sarma and Vittal, 2000).

Chandralata (1999) and Raghukumar and Raghukumar (1998) reported adaptation and activity of terrestrial fungi under marine/ mangrove ecosystem as facultatives or indwellers or residents. Terrestrial fungi are common in mangrove water and mud (Chowdhery *et al*., 1982; Garg, 1983), mangrove leaves (Raghukumar *et al*., 1995), wood (Aleem, 1980), standing senescent stems (Sadaba *et al*., 1995), decomposing mangrove palm (*Nypa fruticans*) (Hyde and Alias, 2000). Terrestrial fungi in deep – sea region of Arabian Sea were recovered (Raghukumar and Raghukumar, 1998). Seawater, sea foam and beach soil of Arabian Gulf Coast, Saudi Arabia yielded terrestrial fungi, typical marine and freshwater fungi (Bokhary *et al*., 1992). Sampling of the leaf litter from the Nethravathi mangroves, India revealed the occurrence of many freshwater Hyphomycetes (Sridhar and Kaveriappa, 1988).

Sarma and Vittal (2000) investigated the fungal diversity of proproots, seedlings and wood of *Rhizophora apiculata* and wood, roots and pneumatophores of *Avicennia* spp in deltaic mangroves of Godavari and Krishna rivers in the east coast of India. The number of fungi recorded on proproots (61) was much greater when compared to wood (24) and seedling (21).

Prasannarai and Sridhar (2001) reported the diversity of marine fungi on intertidal wood collected from 13 locations in the West coast of India was assessed out of 3327 wood samples scanned, of which, 72%, posses sporulating fungi. Altogether 88 species belonging to 47 genera were uncounted. The species richness and diversity was highest in Islands than in beaches and harbour locations. It has been predicted that Islands adjacent to the West coast of India provide critical habitat for marine fungi.

Borse (2002) reported that the distribution and substratum range of 166 species (13 Labyrinthulomycota, 4 Chytridiomycota, 20 Oomycota, 1 excluded sp., 120 Ascomycota, 3 Basidiomycota and 23 mitosporic fungi) of marine fungi recorded so far from India on animal substratum, driftwood, intertidal wood, algae, mangroves, sea grasses, salt marsh plants and as propagules in the sea foams samples. Maria and Sridhar (2002) studied the richness and diversity of filamentous fungi on woody litter of mangrove along the West coast of India. Diversity of fungi in the roots of mangrove species of West coast of India (Ananda and Sridhar, 2002).

Prasannaraj and Sridhar (2003) reported fungi from intertidal wood collected from four coastal locations of the West coast of India. Of the 59 taxa identified, 43 Ascomycetes, 3 Basidiomycetes and 13 anamorphic fungi.

Detritus and live parts of mangrove vegetation have surveyed for the occurrence of higher fungi. In recent – past (up to 2000), 625 fungi encompassing 279 Ascomycetes, 277 mitosporic fungi, 29 Basiomycetes, 3 Chytridiomycetes, 3 Myxomycetes, 14 Oomycetes, 9 Thraustochytris and 12 Zygomycetes have been reported from mangrove forests worldwide (Schmidt and Shearer, 2003). Maria and Sridhar (2003) studied fungal diversity on decomposing biomass of five mangrove plant species from the South West coast of India.

Typical marine fungi were not dominant in root endophytes of coastal sand dunes halophytes (Beena *et al*., 2000), roots of mangrove plant species (Ananda and Sridhar, 2002). The assemblage and diversity of filamentous fungi on leaf and woody litter accumulated on the floor of two mangrove forests (Nethravathi and Udyavara) in the South West coast of India. In their study, yielded 78 taxa belonging to 32 ascomycetes and 46 mitosporic fungi (Ananda and Sridhar, 2004). Sridhar (2005) attempted to deal with occurrence, distribution and diversity of filamrntous fungi in mangrove ecosystem.

Jones *et al.* (2006) reported marine fungal diversity of Thailand was investigated and 116 Ascomycota, 3 Basidiomycota, 28 anamorphic fungi, 7 Stramenopiles recorded, with 30 tentatively identified. These species have primarily been collected from driftwood and attached decayed wood of mangrove trees. The holotype number of 15 taxa is from Thailand and 33 are new records from the country.

Hyde and Sarma (2006) Biodiversity and ecology of higher filamentous fungi on *Nypa fruticans* in Brunei were examined during 1999. Forty-six taxa were recorded including 33 ascomycetes and 13 anamorphic taxa in 25 genera. *Linocarpon* was the most species genus (6 species) followed by *Aniptodera* and *Astrosphaeriella* (4 each). More diversity was found on fronds than on leaves. *Linocarpon appendiculatum*, *L. bipolaris*, *Neolinocarpon globosicarpum* and *Oxydothis nypae* were more frequently recorded on fronds than other fungi, while *Linocarpon bipolaris* (13.5%), *Astrosphaeriella striatispora* (12.2%), *Trichocladium nypae* (8.1%) and *Linocarpon appendiculatum* (8.1%) were more frequently recorded on leaves.

An overview on the diversity and ecology of fungi colonizing litter of mangroves in Bay of Bengal region (mangroves of Godavary and Krishna deltas of Andhra Pradesh, Pichavaram of Tamil Nadu, and Andaman and Nicobar Islands). A total number of 131 species belonging to 77 genera have so far been reported from the three regions. *Verruculina enalia* showed highest percentage occurrence at all the sites and on different hosts. The fungi exhibited vertical zonation in their occurrence with more number occurring in the intertidal zone. While some fungi occurred throughout the tidal range many showed affinity to a particular level. Ascomycetes with immersed or semi-immersed fruit bodies occurred in water inundated niches (Vittal and Sarma, 2006).

Sridhar and Maria (2006) studied that the pattern of colonization and diversity of filamentous fungi on naturally deposited and deliberately introduced *Rhizophora mucronata* Lamk. wood during monsoon and summer in a mangrove of southwest India and compares overall occurrence with three species co-occurrence. Among 17 core-group fungi (≥10 %), *Aigialus mangrovei, Cirrenalia pygmea, Lignincola laevis, Lulworthia grandispora, Passeriniella mangrovei, Trichocladium linderi, Tirispora* sp., *Zalerion maritimum* and *Z. varium* were highly dominant (≥20 %). On wood showing co-occurrence of three fungi, *A. mangrovei, Cirrenalia tropicalis, L. grandispora* and *T. linderi* were highly dominant core-group fungi. Even though *A. mangrovei, C. pygmea, C. tropicalis, Halosarpheia cincinnatula, L. grandispora, P. mangrovei, Verruculina enalia* and *Z. maritimum* are typical marine or mangrove fungi, they were core-group fungi on deliberately introduced wood in monsoon season indicates their high colonization activity on wood even under low salinity. Several terrestrial mitosporic fungi (*Alternaria, Arthrobotrys, Aspergillus, Penicillium, Phoma* and *Tetracrium*) were found particularly in monsoon season, but none of them belonged to core-group.

The distribution of fungi in Muthupettai mangroves along the East coast of Tamil Nadu, India was studied in terms of species diversity, seasonal variation, and frequency of occurrence in five sampling stations at two different seasons. In this study, total of 118 species of fungi isolated, of which maximum 94 species from sediment samples followed by water with 83 species. Among the fungal isolates *Aspergillus* was the common genus followed by *Penicillium, Curvualria* and *Alternaria* (Sivakumar *et al*., 2006).

Fungal biodiversity in freshwater, brackish and marine habitats were estimated based on reports in the literature. The taxonomic groups treated were those with species commonly found on submerged substrates in aquatic habitats: *Ascomycetes* (exclusive of yeasts), *Basidiomycetes*, *Chytridiomycetes*, and the non-fungal *Saprolegniales* in the Class *Oomycetes*. Based on presence/absence data for a large number and variety of aquatic habitats, about 3,000 fungal species and 138 saprolegnialean species have been reported from aquatic habitats. The greatest number of taxa comprise the *Ascomycetes*, including mitosporic taxa, and *Chytridiomycetes*. Taxa of *Basidiomycetes* are, for the most part, excluded from aquatic habitats.

The greatest biodiversity for all groups occurs in temperate areas, followed by Asian tropical areas (Shearer *et al.*, 2007).

Fungi in Marine, Mangrove water and sediment

Single species isolated from mangrove soils, for example, that by Stolk (1955) on an *Emericellopsis* and *Westerdykellaornata* from East Africa and the paper by Swart (1970) on a *Pencillium* from Australia. The thraustochytrids comprise 7 genera and 31 species of marine fungoid protists has been found in estuarine, Littoral, and oceanic waters and sediments around the world. (Gaertner 1967a, 1968a,b; Bahnweg and Sparrow, 1974). Most fungi recorded from marine sediments use collected from coastal regions and are typical soil fungi, which are terrestrial in origin (Borut and Johnson, 1962; Vrijmoed and Hughes, 1990). Ulken (1970, 1972) studied occurrence and physiology of lower fungi from marine sediment in Brazil.

Studied on fungi of soil in mangrove vegetation and investigations on Indian mangal soil were conducted by Pawar and Thirumalachar (1966), Padhye *et al*. (1967), Rai *et al*. (1969), and Rai and Chowdhery (1975, 1976). In India single species isolated from mangrove soil by Rai and Tewari (1963) on *Preussia* isolates, by Pawar *et al*. (1963) on a *Monosporium*, by Pawar *et al*. (1965) on a *Cladosporium* and by Pawar *et al*. (1967) on *Phoma* species. Pawar and Thirumalachar (1966) compared the growth of pure cultures of marine and terrestrial isolates of the same species of soil fungi and concluded that most of the marine isolates grew batter on sea water agar, then on a distilled water medium whereas, the terrestrial isolates of the same specie showed the reverse reaction.

Ulken (1970, 1972, 1975) isolated Phycomycetes from mangrove sediments in Brazil and Hawaii, and Lee and Baker (1972a,b, 1973) investigated soil micro fungi from a Hawaiian mangrove swamp. Nya (1976) revealed qualitative composition of marine fungi from 3 biotopes, water at different depths, bottom sediments, and Macrophytes and the classes of Phycomycetes, Ascomycetes and Deuteromycetes were recorded and the total of 116 species of 41 genera with the greatest variety of species observed in the bottom sediments. The Macrophyte mycoflora comprised 67 species of 28 while in water 64 species of 27 general were found. Kohlmeyer and Kohlmeyer (1979) maintained that most of these fungi are isolated " from dormant propagules and not from actively growing fungi and that isolation methods excluded almost all true marine inhabitat's.

The arenicolous or sand – inhabitating (Kohlmeyer and Kohlmeyer, 1979) draw nutrients from a discrete organic base in the sediment and produce a profusion of hyphae which spread out and grow on the surface of sand grains producing ascocarps strongly adding to them and this space – invading mode of life is one of the characteristics of mycelial fungi and is well known among fungi in terrestrial soils. Kirk (1983) reported that the flotation were devised for the qualitative and quantitative study of marine higher fungi on sandy beach communities. Sample of the water, surface layer, sea foam, and sandy substrates and nearly fresh water body were examined marine fungi were readily demonstrated in the water column and in Neurton screen samples of the ocean surface, as well as sea foam and sand extracts.

Hyde *et al.* (1987) reported the techniques for obtaining sporulation of marine fungi, 65 Ascomycotina, 24 Deuteromycotina, ad 3 Basidiomycotina known to sporulating culture. Jones (1993) revealed the marine fungi appear to be distributed in relation to seawater temperature; arctic, temperate tropical; although others grew equally well over a range of temperature. Christopherson *et al*. (1999) reported that a total of 227 marine isolates of ubiquitous fungi were cultivated on different media and fungi were isolated include 18 different fungal species from 8 Ascomycetes genera from animals, plants and sediments of Venezuelan waters (0 – 10m) including mangroves and lagoon areas.

Occurrence of fungi on different substrata / tissue specificity (wood/twig, pneumatopores, seedlings, leaves and roots

Soft rot in terrestrial known since the middle of nineteenth century and this type of wood decay was later described and illustrated for fungi of marine habitats (Kohlmeyer, 1958). Ritchie (1959) has shown that common terrestrial fungi exist there on submerged wood and other similar substrates. Kohlmeyer (1969a) observed that among large collections, several fungi were encounted only in roots and stems of living *Avicennia* or *Rhizophora* and appear to be host specific. Terrestrial fungi develop on roots and branches above the high – tide line and on over lapping between marine and terrestrial species may occur at the water – air interface (Kohlmeyer, 1969b).

Lee and Baker (1973) demonstrated some of the isolated fungi derived from dormant propagules of terrestrial species.

Johnson (1967) noted that the lignicolous fungi collected in the Neuse – Newport estuary were predominantly of terrestrial origin (73%) and majority of these were from water of less than 18% salinity (81%) while only 12% were recovered from whole estuary i.e. 0- 34 %. Kohlmeyer and Kohlmeyer (1971) listed 51 marine Deuteromycetes and 36 of these are lignicolous and the majority belongs to terrestrial genera (*Alternaria*, *Camerosporium*, *Dedryphiella, Diplodia*, *Humicola*, *Monodictys*), while other exclusively marine (*Cirrenalia*, *Orbimyces* and *Zalerion*).

Ritchie (1968) submerged wood of 8 tropical trees in the Panama canal zone and examined wood sections and found green heart (*Ocotea rodiaei*) and red mangrove (*Rhizophora mangle*) preactically fungus – free after about 6 weeks of exposure and one marine fungi *Lulworthia* species in addition to some 20 Deuteromycetes of terrestrial origin was isolated Kohlmeyer (1969b) reported that the ascocarps of *Keissleriella blepharospora* develop between cork cells of roots or submerged seedling of *Rhizophora* spp. Fell and Master (1973) reported that the senescence of leaf materials, they support a very different fungal community, which are responsible for their degradation.

Rai *et al.* (1969) tested wood decaying potential of twenty-two species of mangrove swamp fungi. The classified these fungi into groups based of on weight loss; above 31% strong, between 28 and 37% - moderate and below 28% weak. Ravikumar and Purushothaman (1998) studied on lignicolous marine fungi in the Vellar estuary, Tamil Nadu and recorded 1 species of Ascomycetces fungus *Corollospora intermedia* which are a new, recorded from India. Few reports of endophytic fungi on substrates collected from the marine environment and these include leaves and droppers of mangrove plants (Suryanarayanan *et al*., 1998; Abdel – Wahab *et al*., 1999; Kumaresan and Suryanarayanan, 1999). Mitosporic fungi and frequent inhabitants of leaves and it is common to find non – marine species such as *Cladosporium cladosporiodes* and *Pestalotiopsis* species in the early stages of incubation and *Pencillium* species and *Trichoderma* species.

The only extensive study of the terrestrial colonization of mangrove seedlings is that by Newell (1973, 1976) investigated the succession of fungi on submerged seedlings of *Rhizophora mangle*. Accordingly the marine fungi encounted in the mangrove habitat live on roots, stems, and twigs submerged in water and their terrestrial counterparts inhabit leaves, stems, branches and upper parts of the roots above the water surface (Kohlmeyer 1974; Kohlmeyer and Kohlmeyer, 1979). Kohlmeyer and Kohlmeyer (1977) examined host plants of *Avicennia germinans* (L.,), *Conocarus erecta* L., *Salicornia virginica* L., *Tamarix gallica* L., *Thalassia testudinum* Koenig and the collections include 15 Ascomycetes, 1 Basidiomycetes and 6 Deuteromycetes which are new records for the Bermuda Islands.

Byrne and Jones (1975) reported that the 28 microfungi which grew on wood blocks of beach (*Fugues sylvatica*) and Scots pine (*Pinus sylvestris*) submerged in seawater at Port Erin, Langstone harbour and Newton Farers were recorded. Schneider (1971) observed 23 species of fungi with the greatest number occurring on beach wood, which also offered the best conditions for rapid development. Quantitative data on the occurrence of tropical marine fungi have been published by Kohlmeyer (1984) and Zainal and Jones (1984, 1986), however all of their reports were on driftwood in the sea along with driftwood on the mangrove floor.

Marine fungi like *Leptosphaeria* species, *Mycosphaerella* species, and *Cirrenalia macrocephala* were for the first time recorded only by direct microscopic observation of the pneumatopores of *Avicenia officinalis* from Indian mangrove habitat by Garg (1982). Hyde (1989c) reported that the decayed archids *Acrostichum speciosum* (Mangrove fern) were collected from Kampong Kapok mangrove, Brunei and examined for higher marine fungi (A new bitunicate ascomycete, *Massarina acrostichi).* Hyde *et al*. (1990) investigated the distribution of fungi on *Sonnertia griffithi* and showed that some fungi were common on pneumatophores (*Aigialus grandis* and *Massarina velatospora*) while others were common on twigs (*Saccarcloella mangrovei* and *Savoryella longispora*).

Kohlmeyar and Vittal (1986) studied marine fungi of the mangal in Belize and India, encounted indepandtly a common Ascomycete (*Lophiostoma* sp.) growing at the upper intertidal level on bark ad wood of mangrove trees. Mouzouras *et al*. (1988) reported the ability of microorganisms to decay wood submerged in the sea and 42 marine fungi, belonging to the Asomycotina and Deuteromycotina have been shown to cause soft - rot decay of wood while 3 Basidiomycotina caused white rot - decay. Pena *et al*. (1996) reported that the first contribution to the knowledge of lignicolous marine fungi from Mardal plata, Argentina .10 species were collected from submerged wood panels, intertidal wood and driftwood.

Studies on marine and mangrove fungi of Indian ocean is quite recent and has been less well explored compared to the Atlantic and Pacific Oceans (Koch, 1986; Borse, 1988, Zainal and Jones; 1986; Hyde, 1988a; Steinke and Jones, 1993). Although Indian sandy beaches, mainland mangroves and some islands have been studied for mangrove and marine fungi, there are few quantitative studies (Borse, 1988; Ravikumar and Vittal, 1996; Prasannarai and Sridhar, 1997, 2000-2001, 2001; Sarma and Vittal, 2000, 2001; Sarma *et al*., 2001; Maria and Sridhar, 2002). Sarma and Hyde (2001) have reviewed factors affecting the frequency of occurrence of fungi in mangroves. A few studies are available on the impact of incubation of lignocellulosic materials collected from different habitat on the occurrence of fungi (Hyde, 1992b; Prasannrai and Sridhar, 1997).

Marine substrata support different fungal assemblages, for example the mangrove palm *Nypa fruticans* and woody tissue of mangrove trees such as *Rhizophora apiculata* and *Avicennia marina*. Typical fungi on *N. fruticans* included *Astosphaeriella striatispora*, *Linocarpon appiculata*, *L. nypae*, *Oxydothis nypae* and *Trichocladium nypae*, taxa never recorded from mangrove wood (Hyde and Nakagiri, 1989; Hyde, 1992a; Hyde and Alias, 2000; Pilantanapak *et al*., 2005).

Hyde (1991) reported *Phomopsis mangrovei*, coelomycetous fungus on proproots of *Rhizophora apiculata* from Ranong mangrove, Thailand. Kohlmeyer and Kohlmeyer (1993) revealed the comparison of the marine mycota of recently introduced *Rhizophora* species (Hawaii and Moorea) with that of long established *Rhizophora* stands from the Caribbean (Belize) and 43 species are known from *Rhizophora* in Belize and only 7 and 21 species were collected from Moorea and Oahu respectively.

Ravikumar and Vittal (1996) reported on the fungi colonizing different substrata of *Rhizophora apiculata* and *R. mucronata* from Pichavaram mangroves of Tamil Nadu, East coast of India and concluded that different substrata of the same host plant are colonized by different frequently occurring fungi. According to Hyde *et al*. (1990b) bark was an important factors in determing the mycota present on *Rhizophora apiculata* particularly when small diameter roots were examined. Young roots surrounded by bark were invariably colonized by *Leptosphaeria* sp., *Lulworthia grandispora*, *Massarina ramunculicola*, *phomopsis* sp. and *Rhizophila marina*.

Poonyth *et al*. (1999) revealed split wood blocks of *Bruguiera gymnorrhiza* and *Rhizophora mucronata* were submerged in the intertidal zone of 5 mangrove sites in Maritrius of the blocks over regular intervals and *Cirrenalia pygmea* and *Lulworthia* species were more common as early colonizer. A relatively high percentage of the fungi colonizing the test blocks were mitosporic fungi. Seasonal occurrence and colonization of intertidel wood and introduced teak wood panels by marine fungi was investigated in mangrove Harbour (West coast of India) of the 33 taxa encounted 29 taxa were found on intertidal wood and 15 species on teak. The most frequently collected species on intertidal wood were *Trichocladium* species, *Zalenion varium*, and *T. alopallonellum.* Sarma and Vittal (2001) recorded the number of fungi on prop roots of *R. apiculata* (61) was much greater when compared to wood (24) and seedlings, 21 from the developing substrate collected from the deltaic mangrove of Godavari and Krishna rivers in the East coast of India.

Borse *et al*. (2000) reported that the higher marine fungi in foam and intertidal wood and dead submerged wood of *Avicennia marina* from Daman coast. In this study 13 species of higher marine fungi (10 Ascomycetes,3 Deuteromycetes) were recorded. Borse (2000) studied that the 83 species (62 Ascomycetes, 3 Basidiomycetes, 18 Deuteromycetes) of higher marine fungi from Maharashtra Coast (The Arabian sea) including 19 species as new records for the fungi of Maharashtra from the substrates include driftwood, intertidal wood harbour timber and dead submerged parts of the mangroves.

Sarma and Vittal (2001) examined the decaying mangrove materials belonging to a host plants species collected from Godavari and Krishna deltas, East coast of India include, 65 Ascomycetes (74%), 1 Basidiomycetes and 22 Mitosporic fungi (25%) (Including 6 Coelomycetes and 16 Hyphomycetes).

Fungi on Seaweeds and Seagrasses

Some of the leaf – inhabiting saprobes occur on rhizomes of the same host as well; for instance, *Lulworthia* species, on rhizomes of *Zostera marina* (Kohlmeyer, 1963) and *Thalassia testudrinum*, (Kohlmeyer and Kohlmeyer 1971). Tubaki and Asano (1965) recorded 16 imperfect fungi on seaweeds most of them as saprophytes like *Dendryphiella qrenaria*, *D. salina*, *Alternaria maritima* and *Monodictys austrina*. *Leptosphaeria* sp., *Pleospora* sp., and *Sphaerulina pedicellata* are all very common on *Spartina* culms by Johnson and Howard (1968). The sporadic occurrence of algicolous fungi may be explained by antibiotic substances produced by healthy algae (Sieburth, 1968).

Meyers (1969) has described a second species of *Lindra* from *Thalassia* species, namely *Lindra marinera* and suggests it may be active in the degradation of *Thalassia* leaves. Meyers *et al*. (1970) suggest that yeast my be active in the degradation of *Spartina* as well as a number of fungi imperfect like *Fusarium*, *Phoma*, and *Nigrospora* sp. Kohlmeyer and Kohlmeyer (1971) have reported *Varicosporina ramulosa*, *Halocyphina villosa*, from *Spartina alterniflora*, *Loisel*, from decaying leaves of *Claviceps purpurea.* Jones (1976) and Kohlmeyer and Kohlmeyer (1979) have revised the occurrence of marine fungi on algae and seaweed though these substrates have not been studied as intensively as fungi on wood tissue. Stanley (1991). Recent reviews of litereature on algicolous fungi have been published by Andrews (1976), Jones (1976) and Kohlmeyer (1974). Kohlmeyer and Kohlmeyer (1979) reported that the *Lindra thalassiae* is the most indiscriminate species of all, as it occurs in leaves of a spermatophyte (*Thalassia)* as well as in air vesicles of *Sargassum* sp.

The rhizoid of Phycomycetous fungi and the ectoplasm that elements of Thraustochytrids penetrate the host cells and draw nutrients and they may also be endoparasites (Chandralata, 1986, 1987). Recent work on *Juncus roemerianus* (Kohlmeyer and Kohlmeyer, 1995, 1996; Kohlmeyer *et al.,* 1995, 1996, 1997) and on *Phragmites australis* (Poon and Hyde, 1998) have resulted in the discovery of a number of species new to science.

Fungi on Sea foams

Kohlmeyer (1966) found that the fungal spores in foam, which is a good indication of the mycota present in the sand of a particular beech. Kohlmeyer (1966) reported that the propagules of marine fungi contained in foam are deposited by the waves on washed – up substrates, such as seagrasses, algae or animal remains. Appendaged Ascospores and Basidiospores , and tetra radiate conidia, are regularly found in sea foam along sandy beaches, mostly together with algae and protozoa (Schlichting, 1971). Kohlmeyer (1966) examined 5 Ascomycetes, one Basidiomycates, and 9 fungi Imperfecti from foam samples collected along shores.

Conidial fungi on sea foams and leaves have been explored from various parts of the world by Bandoni (1972), Barlocher and Kendrick (1977), Crane (1968), Conway (1969), Descals *et al*. (1977), Dudka (1974), Durrieu (1970), Dyko (1978), Gonczol (1975), Greathead (1961), Ingold (1975), Iqbal and Webster (1973,1977), Iqbal (1974), Marvanova (1972), Marvanova *et al*. (1967), Nilsson (1958) and Nawawi (1973, 1975). Presence of fungal spores in foam in aquatic environments has long been recognized by Kohlmeyer and Kohlmeyer (1979), Kirk (1983) and also systamatic investigation fungi in sea foam was carried out on a sandy beach in Viginia.

Recently, Bandoni (1972) reported the occurrence of some of these conidial fungi in terrestrial habitats and 40 conidial fungi were identified and assigned to 20 genera. Kirk *et al*. (1973) reported that the collection ,identification of ecological groups of lignicolous, arenicolous, graminicolous and endocommansalic fungi within the sea foam ,wood and marsh grass plants. The role of conidial fungi in processing of an aquatic litter, energy flow, productivity and experimental aspects of these fungi have been worked out by Barlocher and Kendrick (1974, 1976), Suberkropp and Klug (1976) and Suberkropp and Thomas (1984). Ingold (1975) reported that conidia of most of them accumulate in foam, which acts as a spore trap, and " the examination of a foam samples can very quickly give a picture of the species present in a particular stream above the point of collection". The ecological studies of concerning conidial fungi have emphasized their role in processing litter, energy flow, and productivity in aquatic ecosystems

(Suberkropp and Klug, 1976). Conidiogenesis has been worked thoroughly in some conidial fungi colonizing submerged leaves and foam by Descals *et al*. (1977) and Ingold (1975).

Seafoam generally contains the highly distinctive spores of *Corollospora* sp., C*arbosphaerella* sp., *Varicosporina ramulosa* in tropical and *Asteromyces cruciatus* in temperate areas, *Alternaria* and other terrestrial and marine fungi depending upon climate and local conditions, (Kohlmeyer and Kohlmeyer, 1979; Boyd and Kohlmeyer, 1982). Microscopic counts of fungi, algae, protozoa and in liquefied sea foam demonstrated the potential of the simple and direct approach information of the ecological roles, seasonal and geographic distribution of marine microorganisms (Kohlmeyer and Kohlmeyer, 1979). New geographical limits for several species, the seasonal distribution of tropical *V. ramulosa* and the vertical zonation of *Corollospora* species, deposited by sea foam were less active physiologically than geo fungi and calcicolous marine species in the upper 30cm of the strand line. (Kirk, 1983). A new marine Ascomycte, *Lindra obtusa* and its anamorph, *Anguillospora marina* isolated from sea foam samples on some shores of Japan and appear to be adapted to marine habitats was described by Nakagiri and Tubaki (1983).

Murthy and Manoharachary (1981), Manoharachary and Madhusudhan Rao (1983), Madhusudhan Rao and Manoharachary (1984), Sridhar and Kaveriappa (1982) and Subramanian and Bhat (1981) have studied the conidial fungi associated with foam and submerged leaves. Sridhar and Kaveriappa (1982) have studied the conidial fungi associated with foam and submerged leaves. Mahusuhan Rao and Manocharachary (1984) have reported the association of conidial fungi on diversified submerged leaves.

Patil (2003) reported that the submerged leaves of *Memmeaylon umbellaun* and *Mangifera indica* were colonized by species of *Alastospora*, *Beltrana*, *Flagellospora*, *Ingolidiella*, *Lemonniera*, *Lunulospora*, *Monosporella* and *Triselophorus* along with these fungal forms of species of *Actinospora*, *Angiullospora*, *Cameroporium*, *Caluariopsis*, *Spelroplis*, *Tetrachacum* and *Tetraploa* are also isolated in foam samples. These conidial fungi play important role in processing aquatic litter, energy flow and productivity.

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