

MARINE FUNGI

S. Raghukumar

National Institute of Oceanography, Dona Paula, Goa.

Fungi are eukaryotic microorganisms possessing a heterotrophic mode of life similar to the bacteria. For their nutrition, fungi take up simple organic compounds osmotrophically through their cell surface. Complex organic compounds are broken down to simpler substances by hydrolytic enzymes before they are absorbed. Fungi may be unicellular or multicellular and filamentous. The fungal filaments or hyphae (sing. hypha) go to form the fungal mycelium. There are five major groups of fungi, the Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina. Another group, the Thraustochytrids are similar to fungi, but their true affinities are not known (Deacon, 1980, Moss, 1986).

Fungi have been found in most parts of the sea. They can be isolated from various substrates in the estuarine, coastal and offshore environments, including dead and living organisms, waters and sediments. However, marine fungi have been studied mostly from the coastal and estuarine environments and much less is known about those in the oceanic environment (Jones, 1976; Kohlmeier and Kohlmeier, 1979; Moss, 1986).

Since fungi elaborate hydrolytic enzymes, they are capable of degrading dead organic matter and remineralization of nutrients which are tied up in complex molecules and thus recycle them for use by primary producers. Besides this important potential role, fungi are involved in several other activities in the sea. These include: (1) Detritus formation; (2) Parasitism of marine plants and animals; (3) Biodeterioration of materials.

These activities of fungi are discussed in greater detail below.

1. Role of fungi in detritus formation: Detritus comprises dissolved organic matter lost from living and dead organisms, the particulate organic matter arising from death and excretion of living organisms and the microorganisms associated with these. Marine macrophytes, such as mangroves, seagrasses and macro-algae are major sources of detritus in the coastal environment. Such substrates hardly seem to be grazed upon when living and are not suitable as food for marine animals (Barnes and Mann, 1980; Moriarty *et al.*, 1987). However, their detritus is avidly fed upon by many detritivorous animals in the sea. The biochemical transformations brought about by microorganisms while decomposing and growing on the dead macrophytes and the biomass of the microorganisms themselves are considered to be the major reasons for the enhanced nutritional value of detritus.

Fungi are extremely common in detritus of several marine macrophytes. The decomposition of mangrove leaves and mangrove seedlings which contribute a

great deal to the input of detritus in tropical coastal waters has been studied in detail (Fell and Master, 1980; see also Newell in Jones, 1976). Decaying mangrove leaves and seedlings are extensively colonised by mycelial fungi. Initially, terrestrial species of fungi such as Pestalotia sp. and Cladosporium sp. which are already present on the senescent leaves, rapidly colonise them when they are shed into the water. Many other species of fungi in the water, such as Phytophthora sp. also begin to colonise such leaves. At a later stage of decomposition, obligate marine species of fungi like Lulworthia sp. pervade the decaying tissues and establish their biomass, followed once again by many terrestrial species, eg., Trichoderma and Penicillium sp. Such a colonisation results in a decrease in the C:N ratio of mangrove detritus, more suitable as feed for detritivores. The fungal succession results in a sizeable buildup of fungal biomass in detritus from mangrove leaves and seedlings.

Fungi are important in the decomposition of the salt marsh grass, Spartina alterniflora Loisel. Fungi form a significant part of the biomass in dead parts of this plant. Using modern techniques such as the Enzyme Linked Immunosorbent Assay (ELISA), estimation of the biochemical indicator for mycelial fungi - ergosterol and direct observation techniques, Newell and co-workers have arrived at a fungal biomass contribution of up to 50% in salt marsh grass detritus (Moss, 1986).

Seagrasses form substantial amounts of detritus in many coastal areas. Although not as well studied as the above mentioned substrates, fungi have been reported in the turtlegrass Thalassia testudinum Koenig (Newell and Fell, 1980).

2. Parasites: Marine plants are subject to diseases caused by fungi. Such diseases are common in nature (Andrews, 1976). The eelgrass, Zostera marina may be severely attacked by Labyrinthula sp., causing the wasting disease (Short et al. 1987). This fungus has been claimed to have wiped out vast populations of the seagrass from temperate coastal areas. Macroalgae, for example, the brown alga Sargassum sp. may be parasitised by Ascomycetes such as Lindra thalassiae (Kohlmeyer and Kohllmeyer, 1979). Zoosporeic or phycomycaetous fungi, belonging to the Mastigomycotina are very common in filamentous algae and several are known from the tropical coastal waters of India (C. Raghukumar, 1987). The disease incidence may dramatically increase depending on the season. Thus, the monsoon season has been found to be very favourable for many fungal diseases of algae along the Goan coast of India. The role of these diseases in determining the population levels of such algae has not been worked out in detail.

Fungal diseases of algae in aquaculture systems may turn out to be important in future. The best examples of such a disease are that of the fungus Pythium porphyrae Takahashi in Porphyra sp., the edible 'Nori' cultivated in Japan and that of Petersenia pollagaster (Petersen) Sparrow in the red alga, Chondrus crispus Stackh. cultivated for agar.

Many fungal diseases of marine animals, particularly of invertebrates are coming to light in recent years (Alderman and Polglase in Moss, 1986). Eggs and developing larvae of crustaceans are parasitised by a variety of oomycetous (Mastigomycotina) parasites, such as species of Lagenidium. This is of concern in hatcheries for aquaculture. Another common crustacean parasite is Fusarium sp., belonging to the Fungi Imperfecti (Deuteromycotina). Ichthyophanus, a genus of uncertain fungal affinities is a well known fish pathogen.

3. Fungi in the water column: The most important group of fungi in the water column are the thraustochytrids. Numbers of thraustochytrids in the water column could vary from 11,000 per litre in the coral reef waters to a few hundreds or tens in coastal and offshore waters (Raghukumar and Gaertner, 1980 Raghukumar, 1987). However, the techniques to isolate and enumerate these organisms have still not been adequately developed. Yeasts, belonging to Ascomycotina, Basidiomycotina and Deuteromycotina are also common and range from 10s to 100s in various waters. Certain yeasts may show geographical distributions (see Fell in Jones, 1976). Yeasts are known to increase significantly in numbers when a phytoplankton bloom is present. The role of thraustochytrids and yeasts in the water column has not been adequately studied. They may be involved in detritus formation from dead phyto- and zooplankton and also as parasites of these organisms.

4. Fungi in the marine sediments: Intertidal beach sediments harbour 'arenicolous' fungi. These fungi, mostly belonging to the Ascomycetes, grow between the sand particles and produce fruit-bodies or ascocarps firmly attached to the sand grains. They derive their nutrition from organic particles in the sediment (Kohlmeyer and Kohlmeyer, 1979). Several terrestrial species of fungi have been isolated from sublittoral sediments, both neritic and oceanic. Their numbers, importance and activity in such sediments has hardly been investigated. Thraustochytrids are extremely common in marine sediments. They have been recovered even from sediments at 3000 m depth and may occur in numbers up to 73,000 cells per liter sediment.

5. Biodeterioration of materials: One of the most well studied aspects of marine mycology is the biodeterioration of wood in the sea by marine fungi (Kohlmeyer and Kohlmeyer, 1979; Moss, 1986; Mouzouras et al. 1988). Timber immersed in the sea is invariably attacked by fungi, mostly belonging to the Ascomycotina and the Deuteromycotina. The sexual spores of the former group, the ascospores, possess a wide variety of sticky, gelatinous appendages which help them adhere to the wood. The hyphae produced penetrate the wood cell walls and cause rot. Most marine lignicolous fungi cause 'soft-rot' decay, in which the fungal hypha penetrates the secondary cell wall of the wood elements and grow within them. They produce lignocellulases, which break down the lignocellulose components of the cell wall (Mouzouras et al., 1988). These fungi are suspected to assist the wood-boring crustaceans and teredinids, the major wood destroyers in the sea in two ways. Wood-boring crustaceans may reproduce better and survive longer when they feed on fungus-infested wood. The larvae of the shipworms seem to prefer wood which has been softened by fungi for settlement (Eaton, in Moss, 1986). Activity of the wood-degrading

or lignicolous marine fungi is therefore of special interest and may have considerable economic significance in the protection of wooden structures in the sea, such as small fishing craft and harbour structures. In this connection, it is important, particularly in the tropical countries to investigate the resistance of various species of timber to marine fungal attack, the effect of preservatives on marine lignicolous fungi and the real association between wood borers and marine fungi.

Marine fungi may be capable of heavily colonising man-made materials such as polyurethane submerged in the sea. Jones and Campion-Alsumard (see Jones, 1976) reported such an infestation even at 537 m in the Atlantic.

Yeasts are capable of active hydrocarbon degradation. Ahearn and Crow suggest that yeasts and other fungi may be important in degrading oil at specific sites, such as surface films, decomposing algae and tar balls (Moss, 1986).

Summary: Fungi form a common component of the marine microflora. Most studies on marine fungi have been confined to the coastal environment, where their substantial presence in detritus of marine macrophytes and as parasites of marine plants and animals have been reported. Fungi also occur commonly in the waters and sediments of the coastal and offshore environments. The exact biomass in various substrates and role of fungi in different processes in the sea are of immediate interest. Fungi are important in biodegradation of materials such as wood and are commonly associated with hydrocarbons in the sea.

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