

## **Marine fungi: a critique**

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**(as appeared in Aquatic Microbiology newsletter)**

### **Abstract**

Obligate marine fungi, those which grow and sporulate exclusively under marine conditions, have received all the attention from marine mycologists. Fungi originating from freshwater, or terrestrial environment and capable of growth and sporulation in the sea have been ignored to a large extent. However, several instances of terrestrial species of fungi, active in marine environment have been reported. We present arguments to support the view that terrestrial species of fungi by virtue of their physiological versatility, play a greater role than the obligate marine fungi in the sea and thus, deserve much more attention than what they have received till now.

## MARINE FUNGI: A CRITIQUE

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The seminal paper of Barghoorn and Linder (1944) drew the attention of mycologists and marine biologists to the existence of a unique group of filamentous fungi in wood submerged in the sea. These lignicolous fungi, comprising Ascomycetes, Basidiomycetes and Deuteromycetes, have distinct spore structures that set them apart from their terrestrial counterparts. Marine filamentous fungi are also known from algae, detritus of marine macrophytes and corals. Kohlmeyer and Kohlmeyer (1979) defined these obligate marine fungi as "those which grow and sporulate exclusively under marine conditions." The fact that they are found only in the sea and that their profuse growth and sporulation in marine substrates can be microscopically verified leaves one in no doubt about their ecological importance. The discovery of more than 200 such marine species in the last fifty and odd years led to a great excitement among mycologists. Understandably, therefore, research on marine mycology has almost entirely revolved around studies on the taxonomy, ecology, physiology and, in recent years, biotechnology of such fungi. Do ecological conditions of the sea deter terrestrial species and permit only obligate marine fungi to grow? This question has frequently been debated.

In order to accommodate the possibility that terrestrial species might also be active in the sea, Kohlmeyer and Kohlmeyer (1979) offered a definition for 'facultative marine fungi', as those originating from freshwater or terrestrial environment that are also capable of growth and sporulation in the sea. However, several basic questions regarding "facultative marine fungi" remain to be answered. (1) First and foremost, do terrestrial species of fungi grow and sporulate at all in the sea?

(2) If they do, is their ecological role significant enough for a mycologist / microbiologist to bother about them? One of the major reasons why no answers to these questions have come forth during the fairly long period of marine mycology, is that all reports of terrestrial species of fungi in the sea, such as those of Roth et al. (1962) from the Atlantic Ocean waters, Miller and Whitney (1981) from the Bay of Fundy in Canada, Buchalo et al. (1997) from the Dead Sea waters, Gessner (1982) from detritus of the salt marsh grass and Raghukumar et al. (1993) from detritus of mangrove leaves, have been based on cultural studies. Isolation of a terrestrial species of fungus in culture from a marine substrate does not guarantee that it is active there. It is quite likely that dormant spores washed into the sea from land, and not actively growing mycelia, result in colonies when cultured. Growing mycelium of terrestrial species, bearing sporulating structures have not been observed in marine substrata so far, the way one may observe a fungus on terrestrial litter, or an obligate marine fungus on wood. As a consequence, marine mycologists have, to a large extent, tended to ignore the question of terrestrial species occurring in the sea.

However, we believe that there is now substantial evidence to take the issue of "facultative marine fungi" seriously. Despite rigorous surface sterilization that removes surface-contamination of spores, and despite the fact that such a treatment may still not completely decontaminate the surface, terrestrial species turn out far too regularly from

macrophytic detritus to be dismissed lightly. Are they only microcolonies within detritus, or do they play a larger role? Following surface sterilization, we have consistently isolated *Aspergillus ustus* and *Graphium* sp. in culture from carbonaceous sediments and calcium carbonate shells (Raghukumar et al., 1992).

Recently, we isolated *Aspergillus sydowi* from sediment core of 3.5 m length obtained from 5,500m depth in the Central Indian Ocean. This fungus occurred as sterile mycelium at the initial isolation stage in 1/5 diluted malt extract agar prepared with seawater, and later sporulated under different cultural conditions. It showed germination of spores and growth of mycelium in dilute media under elevated hydrostatic pressure of 300 bars and low temperatures of 10°C. A few terrestrial species of fungi have been very regularly isolated by us and in high densities from marine sediments.

Several instances of geofungi as pathogens of marine organisms have been reported, such as the occurrence of an *Acremonium* sp as pathogen of green alga (Bott & Rogenmuser, 1989). A species of *Scolecobasidium* and *Ochroconis humicola* causing fish disease were reported by Ross & Yasutake, (1973) and Schaumann & Priebe, (1994) respectively. A species of *Scolecobasidium* was found to be associated with necrotic patches in massive corals (Raghukumar & Raghukumar, 1991). Smith et al. (1996) reported an *Aspergillus* sp causing mass mortality of seafans in the Caribbean. A number of geofungi were isolated in culture from live corals (Kendrick et al., 1982; Raghukumar, personal observation).

It is surprising that terrestrial species are considered incapable of adjusting to marine conditions by many, even while their astounding metabolic versatility is widely accepted. If they can adapt to extreme microaerophily, xerophily and oligophily, there is no reason why the numerous reports of the geofungi in the sea should not be taken seriously.

Sporulating structures of terrestrial species such as those of *Aspergillus* are essentially adapted for aerial transport of spores and are not suited for aquatic conditions. We consider it very likely that such species have modified means of propagation in the sea and perhaps occur mostly as sterile mycelia. Therefore, it may not be possible to discern sporulating structures of many terrestrial species in the sea. It is necessary to apply immunological, or molecular probes to address the question of detection, occurrence and role of terrestrial species in the sea. In situations such as the deep-sea, it is possible that terrestrial species of fungi play a greater role than hitherto summarized, perhaps exceeding that of the "obligate" marine fungi. We contend that terrestrial species of fungi in the sea deserve much greater attention than what they have received till now.

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zones. The interaction between eucaryotes and bacteria -which may or may not be of symbiotic nature - may result in the production of secondary metabolites, which may be originally used as toxins or in chemical communication. Of particular interest are endocytic (intracellular) bacteria, e.g. such as those recently found in the dinoflagellate *Noctiluca scintillans*. In cooperation with the universities of Gottingen and Tubingen, the cultures will be tested for their pharmacological effects and the chemical structure of the natural products will be determined. Many infectious diseases are still difficult to treat and increasing bacterial resistance to antibiotics emphasize the need for new compounds with antibiotic and anti-tumor properties. Secondary metabolites from endocytic bacteria could also be potentially useful for industrial purposes.

Our team of microbiologists in the search for these compounds include T.L. Tan and E. Helmke from Bremerhaven, and G. Gerdt, M. Kirchner, R. Kuhlenkamp, C. Schutt, A. Wichels, and S. Yasseri from Helgoland. Our investigations are also continuing on bacteria associated with algal blooms, including *Noctiluca scintillans* and toxic *Alexandrium* species. Three of our team will attend the "International Conference on Harmful Algal Blooms" in Tasmania, Australia. Sep 7-11, 2000.

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Scientists from the Alfred-Wegener-Institute for Polar and Marine Research (Bremerhaven), to which the Biologische Anstalt Helgoland now belongs, are keenly interested in the search for marine bacteria which produce bioactive natural products. The isolation and cultivation of such "creative" groups of bacteria will be intensified during the next few years, with special emphasis on bacteria from polar regions (including ice) and those associated with marine organisms in temperate

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### Current Research:

- Collecting marine macroorganisms in the eu- and sublittoral of Helgoland and cold temperate zone of the North Sea by means of SCUBA diving
- Identification of samples and their taxonomic evaluation;
- Short-term storage of live material in seawater tanks
- Long-term cultivation of certain species under different environmental conditions for testing the best conditions for producing secondary metabolites
- Use of micro-electrodes measuring physiological parameters (pH, O<sub>2</sub>, redox, H<sub>2</sub>S) for quantifying internal and surface conditions of macroorganisms for the establishment of culture conditions of the isolated exo- and endocytic bacteria.

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