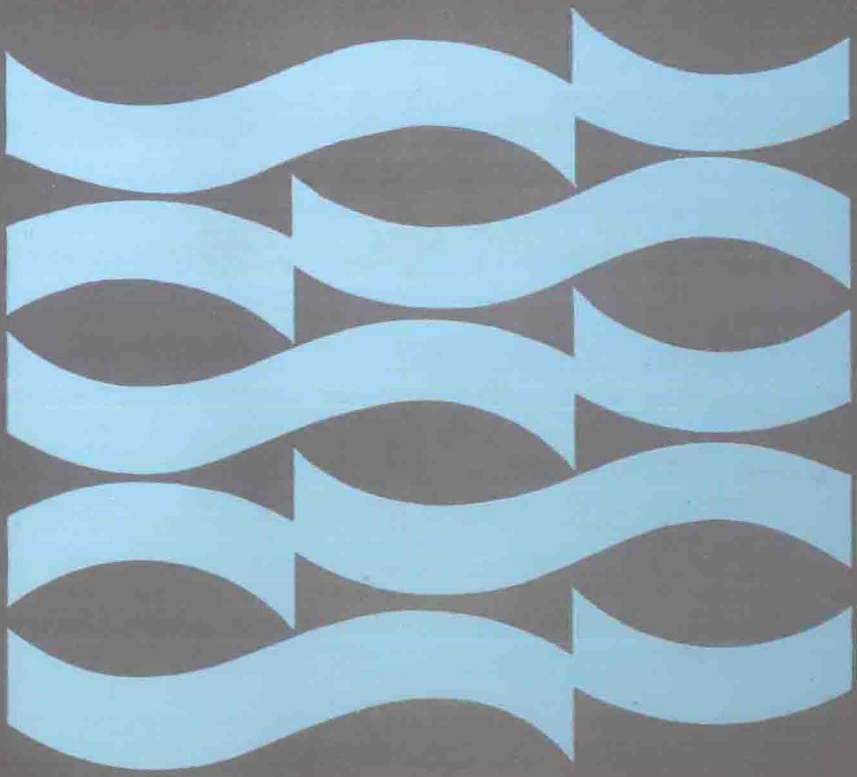
Aquatic Ecology



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Preface

The water is not merely one of the four elements of the ancient saying, but it is one of the basic resources of civilization and forms the life-blood of all living organisms on the earth. The attitude of humanity to water depends on its abundance and its plentifulness. It is accepted by many as a gift of God, freely available for whatever purpose and whenever needed. Scarcity of water becomes a matter of public concern, an issue of disputes and even fights between its users. Civilization have displayed all shades of attitudes between these two extremes. Increasing of population, expand industries, need of higher agricultural production and modern living standards have increased water consumption as never before. Though late, but still not very late the water is now increasingly appreciated as a vital resource, which needs care and attention to remain available not only for the present but also for the future generations.

The organisms are totally dependent upon their environment for their sustenance and are inseparably related to it. In other words, the environment refers to the surroundings of an organism which have direct influence on the activities of the organisms. Thus, the relationship existing between the organisms and the environment is of reciprocal nature.

The aquatic environment has attracted the attention of researchers in India for past several decades and lot of good work is being done. The present volume is intended to bring on record of the ecology and pollution problem of different aquatic environment namely rivers, lakes and pond etc., their fauna, flora, production potential and impact of pollution on them.

We express our deep sense of gratitude to Prof. J. Bahadur, Head, Department of Zoology and Rector, Jiwaji University, Gwalior for his affectionate encouragement. We are greatly indebted to all those who have contributed to this volume. Our sincere thanks are due to Mr. S. Kaushik, Research Fellow, Jiwaji University, Gwalior for his help in many ways and Mr. S.B. Nangia, who have taken keen interest in the publication of this book.

—Editors

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On the Ecology and Role of Different Communities of Fungi in Aquatic System

K. Wadhwani, Shantau Chatterjee and Sushil Kumar Srivastava

INTRODUCTION

Ecology of fresh water fungi has not attained the degree of prominence as the ecology of soil fungi, because of latter's significance in phytopathological studies and agriculture. The qualitative composition of the fungal population in water is now becoming fairly well-known.

There are two spheres of aquatic environments, the benthic at the bottom and planktonic, the floating. Both are connected with physical and chemical nature of aquatic environment. Heterotrophic organisms are usually present in natural water in direct proportion to the amount of organic matter available. Where oxygen is in abundance, a wide variety of aquatic fungi, such as Chytridiomycetes, Saprolegniales and Peronosporales are found. Till 1942 whatever information was available, it was mainly in relation to 'Oosporic Phycomycetes" or "water molds", which till then were regarded as true water fungal flora. In 1942 Ingold reported a distinctive and abundant flora of conidial fungi with distinct shape and structure and were well adapted to aquatic habitat on submerged and decaying leaves of *Alnus glutinosa* in the bed of a stress in England as aquatic hyphomycetes. At about the same time, Glen-Bott (1951) recognized another assemblage of aquatic hyphomycetes as aeroaquatic fungi with the mycelium in

submerged decaying leaves, including those in stagnant water and sporulate when brought above water surface. Cooke (1961, 1963) divided the fungi encountered in fresh water into two principal groups, the hydrofungi, which required the presence of water to complete their life cycle and the geofungi or typical soil fungi which were not specifically adapted to and aquatic existence but nevertheless might be found in water because of an adequate supply of nutrients. These were regarded as "facultative aquatic fungi".

Thus, there are at least four groups of fungi, which are active in aquatic systems in different ways, these are the true water molds comprising :—

1. Chytridiomycetes, Oomycetes compiled as Mastigomycotina and some Zygomycotina.

2. Aquatic Hyphomycetes found on decaying leaves of deciduous trees in well aerated waters which are taxonomically unrelated forms, though most of them resemble one another in the production of conidia with projecting arms or consisting of a curved or branched rows of cells. Their shape is well adapted to their habitat and readily become entangled in submerged leaves which they colonize after germination.

3. Aeroaquatic Hyphomycetes is an assemblage of aquatic hyphomycetes with the mycelium in submerged decaying leaves, especially in stagnant water. They do not sporulate below water, but, when leaves are brought above water they sporulate. Many of these fungi have a terrestrial potential and apparently limited terrestrial occurrence.

4. Terrestrial or Geofungi are typical soil fungi belonging to Moniliales, Sphaeropsidales and yeasts which are metabolically active in aquatic conditions and appear to be sufficiently versatile to operate facultatively in either environment.

The distribution, biology, ecology and the role of fungi of four groups in the decomposition and simplification of organic matter forms the basis of this review.

Mastigomycotina : This comprises Chytridiomycetes and Oomycetes which are prevalent in aquatic habitats and are collected by special

techniques (Emerson, 1958; Sparrow, 1960; Fuller and Poynton, 1964; Miller, 1967; and Fuller, 1978). The Chytridiomycetes parasitize and destroy algae that form a link in the food chain of aquatic animals. Many species of Coelomomyces parasitize mosquito larvae. The early comprehensive and fundamental monographs on this group known as "Aquatic Phycomycetes" or water molds are of Sparrow (1943, 1960) and Karling (1935, 1966-1968), Canter (1960, 1966, 1968) and Willoughly, 1962).

The origin in studies in aquatic phycomycetes could be traced in mid early this century in Europe with Germany as its centre. We will not go into the details of it as it has been very adequately summarised by Das Gupta (1982) in his "Discourse of Aquatic phycomycetes in India", presenting the list of genera and species worked out and being worked at various centres in India. (The only lacuna is the citation of literature). In the post war era along with European researchers emerged important workers in United Kingdom (Cook, 1926; Blackwell, 1937; Ingold, 1940; Canter, 1948; Waterhouse, 1940; Goldie Smith, 1956) each with many contributions. In United States these studies flourished with the studies of Coker (1923, 1937), Johnson (1956), Seymour (1956), besides Karling and Sparrow. In East, Japanese work has been compiled by Kobayashi and others (1954, 1971), significantly the life history, cytology and host parasite relationships, of the members of Woroninaceae, Olpidiaceae, Lagenidiaceae, *Monoblepharis, Allomyces* etc.

In India studies on water molds started with the arrival of E.J. Butler with his special interest in the genus *Pythium*. In 1907 he published a memoir "An Account of the genus *Pythium* and some Chytridiaceae" in which he distinguished 18 species of *Pythium* five were from India itself. Out of eleven chytrids, the four (*Nowokowskiella ramosa, Pseudolpidium aphanomyces, Olpidiopsis minor* and *Olpidiopsis schenkiana*) were from India. Butler (1911) established a new genus *Allomyces* to accomodate *A. abrusculus* in family Blastocladiaceae. The studies of Chaudhury and Coworkers (1931-47) resulted in the discovery of seven more genera (*Pythiopsis, Isoachlya, Protoachlya, Achlya, Aplanes, Thraustotheca and Hamidia*) in addition to *Saprolegina*. Iyengar (1935) described two species of *Coelomomyces*. There was simultaneous development in taxonomic studies of aquatic phycomycetes in

Lucknow and Patna (1949-1958) under the able guidance of Prof. Dasgupta and R. John resulting in the isolation and description of many membners of Chytridiales, Blastocladiales, Monoblepharidales, Lagenidiales and Entomophthorales. After a gap of few years these studies were continued, by his student Rai and Coworkers (studied the occurrence of aquatic phycomycetes in alkaline and saline soils). The other centres were Gorakhpur (Bhargava, Sirvastava and Srivastava, Singh, Prabhuji, 1963-1977); Varnasi (Singh and Pavgi, Dayal, Thakurji, Ushakiran and others from 1970 and onwards). All these data have been compiled by Bilgrami *et al.* (1979) in his monumental compilation "Fungi of India". From time-to-time many workers added to the knowledge of aquatic phycomycetes from various centres Khulbe and Bhargava, 1977, Dayal and Ushakrian 1978, 1979, 1980a, b; Ushakiran and Dayal, 1982; Hasija and Khan, 1982; Chowdhry and Agarwal, 1981; Khulbe and Sati, 1979; Khulbe, 1981; Manoharachary, 1985; Prabhuji *et al.*, 1984; Prabhuji and Srivastava, 1978.

It is now commonly known that water molds are not only found in pools, ponds, lakes, rivers, streams and bogs, but also in marginal as well as strictly terrestrial habitats (Apinis, 1964; Dick, 1966 ; Papavizas and Davey, 1960; Cantino, 1966; Park, 1980).

Saprolegniales and chytrids found on algae and other fungi utilize organic materials produced by autotrophs. Fungi initiate and carry out the destruction of Photosynthesizers as well as non-photosynthesizers in aquatic environment (Peterson, 1910; Paterson, 1960, 1967). The most important aspect, which developed simultaneously was the involvement of fish diseases associated especially with species of *Saprolegnia* (Tiffany, 1939a, b; Tiffany and Wolf, 1937; Vishniac and Nigrelli, 1957; Scott, 1964; Scott and O'Bier, 1962; Scott and O'warren, 1964). Mycotic infection in fish starts when host is injured. The severe infections result in large scale morality in hatcheries, impoundments and fish rearing centres. Malnutrition and overcrowding usually lead to debility and enhance the susceptibility of fish to fungal attack (Srivastava, 1980; Srivastata *et al.*, 1983). Till mid-seventies most of the workers reported and were under the impression that only the species of *Saprolegnia* caused mycoses in fish, except one report of Shanor and

Saslow (1944) who reported *Aphanomyces* also as the causal organism, later Gopal Kirshnan (1963, 1964) Bhargava *et al.* (1971) and Srivastava and Srivastava (1976-1978) also found species of *Aphanomyces* along with *Achlya* and *Dictyuchus* as fish pathogens. Srivastava (1980) during his investigations for the host range of *Achlya diffusa* reported ten fresh water fish (*Puntinus sophere, P. ticto, P. conchonius, Colisa latia, Labeo rohita, L. bata, L. Calbasu, Cirrhinus mringala, Anabas testudineus* and *Channa punctatus*) as its hosts. He (Srivastava, 1980) also observed that *Heteropneustis fossilis* with a deep body cut inflicted with *Achlya diffusa*, could recover and survived for a long period in fresh water when fungus was removed completely from infected part. Mer *et al*, (1981) isolated a Saprolengial, *Leptolegnia caudata* from the infected eggs of *Cyprinus carpia* as a parasite in Bhimtal, Nainital. In pathogenisity test they observed that in controlled inoculation about 70 per cent infected eggs did not hatch. Prabhuji *et.al.* (1985) reported *Allomyces anomalus,* a water mold from eggs and fingerlings of *Channa punctatus.* This fungus occurs as a saprophyte in wet soil but under certain condition it may become a parasite exhibiting a facultative parasitism. Smith *et al.* (1985) reported that *Saprolegnia declina* and *S. ferax* zoospores only infected dead trout egg in particular eggs sited down stream of the fungi, Susceptibility appeared to be associated with nutrient loss after shocking, living and dead eggs were colonized by hyphae of both species, though a parasite, S. *ferax* being more aggressive. Sati (1986) reported two species of *Achlya, A. flagellata* and *A. orion* pathogenic on two new hosts *Tor tor* and *Barlius dendelisis* respectively.

For the last one decade considerable attention has been paid to the various aspects of Saprolegniales, especially their fine structure, life cycle, relationship to environmental factors with respect of fish diseases, especially the zoospore behaviour, the nutritional physiology (Bhargava, 1943; Beakes, 1980; beakes *et al.*,1980; Dayal, 1960; Pickering *et al.,* 1979; Reischer, 1951; Smith *et al.*, 1984; Willoughby, 1962, 1977, 1978, 1983, 1984; Willoughby and Copland , 1984; Willoughby and Pickering, 1977; Willoughby *et al.*, 1984). With the help of electron microscope, Beakes (1980) studied the oospore maturation and germination in an emasculated isolate of *Saprolegnia farex.* Pickering *et al.* (1979) on the basis of fine structure of secondary zoopore cyst cases of *Saprolegnia diclina*

isolates from infected fish divided them in three sub-divisions LIC 10, P 203, and E 3.

Achlya, Aphanomyces and *Saprolegnia* do have the ability to utilize ammonia N (Cantino, 1966). The possible chemical substances, which stimulated growth of zoospores of *Saporlegnia* isolate 847 were, ammonia, bound phosphorus and organic acids in lake water at overturn (Willoughby *et al.*, 1983). Who discussed the possible relevance of readiness of motile secondary zoospore to germinate in low nutrients, when in contact with the mucus surface of potential fish host. The indirect germination might have been device to extend the length of the germling economically in water and to increase its efficiency in locating the host. The numbers of zoospores produced and behaviour of pathogenic strain of *Saprolegnia diclina* were markedly affected by temperature, pH, oxygen tension and presence of biocides, the use of the nutrients, such as, aspartic and glutamic acids at equivalent concentration occurring in fresh tissue encouraged the colonization of fresh sites. Smith *et al.* (1984) did mot recommend the use of biocides as fish readily succumbed to equivalent concentrations of biocides. Kaphalia *et.al.* (1986) found that all the 51 samlesh of fish from River Gomti in Lucknow were positive of contaminants. DDT and HCH residues and suggested that such species of fresh water could be used as biological indicators of pesticide contamination in the aquatic environment. Willoughby (1936) demonstrated that in the aquatic fungi 'water' not merely carried zoospores of 'Salmonid *Saprolegnia'* but also sustained diminutive but complete vegetative life cycle. Willoughby and Hasenjager (1987) observed the formation of appressoria in *Saprolegnia* in culture media at hyphal apices which are attracted to the substrata by chemotropism and designated them for saprophytic role to extract nutrients from substrata and did not require haustoria. Mature appressoria could give rise to fresh mycellium directly. Hood and Robinson (1989) reported the formation of aerial hyphae in *Saprolegnia ferax* from the tip region of surface growing upwards on solid media and showed experimentally that these aerial hyphae were negative autotrophic. The evidence was presented for self-produced metabolities that induced the formation of aerial hyphae. *Pythium* species are often pathogenic to many plants and animals, such as fish or Crustacea Van Der Plaats-Niterink (1981) presented a

condensed data about geograhic distribution and pathogenicity of each species acknowledging the work of Rangaswami (1962) and Tomkins (1975).

The species of *Pythium* are reported to cause infections in horse. In veterinary language the etiological agent of equine phycomycosis or swamp caneer and bursatte was known as *Hyphomuces destruens-eqi* and the species was never described as no sporulation could be observed. It was recognized as a Phycomycetes. Bridges and Emmons (1961) considered it as possibly belonging to *Mortierella.* Austwick and Copland (1974) could obtain the fungus into water, by baiting or rotten maize silage and observed *Phythium*-like sporangia and zoospores. The detailed studies of the isolates from different countries. (Austiwick and Copland, 1974; Ichitani and Amemiya, 1980; Shipton *et al.*, 1982) indicated that etiological agent was *Pythium,* whether all strains were similar or not was not known (Shipton *et al.*, 1982). Shipton (1985) studied the condition during the induction on phase favouring sporangia and zoospore formation in *Pythium* isolate causing equine phycomycosis. Media containing glucose, sucrose, maltose and xylose in certain concentrations induced zoospore formation and salts such as $CaSo_4$, NH_4Cl and mono and di-basic potassium phosphates when present singly inhibited it. Sitosterol also stimulated zoospore production in indication medium.

A wide range of taxonomically different fungi cause diseases of insects and other arthropods, but relatively few have been studied to-date. These include some members of Chyridiomycetes (species of *Coelomomyces*), Trichomycetes, Entomophthorales and Zoopagales. *Coelomomyces* is an obligate parasites found in the coelom or mosquito larvae, belongs to the Blastocladiales (Alexopoulos and Mims, 1979). Since its establishment by Keilin (1921), till 1944 it was studied by entomologists and parasitologists. In 1944 Dr. J.N. Couch found several new species of *Coelomomyces* associated with mosquito larvae, received from war area malaria control personnel in Georgia. Couch (1945a) revised the genus, placed it in Blastocladiales with in excellent historical account. Umphlett (1962) has briefly summarised this account, while reporting the results on morphological and cytological observation of the mycellium in two species of *Coelomomyces, C. dodgei* and