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Fungal diseases in aquaculture: A review

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Abstract
In recent years, there has been an increase in emerging and re-emerging diseases that have resulted in significant economic losses for various global aquaculture industries. Aquatic fungi are frequently regarded as secondary tissue invaders that occur after traumatic injuries, pathogenic agents, or environmental conditions such as poor water quality or low temperatures. Many fungi are common in the aquatic environment because they feed on decomposing organic waste. Saprolegnia and other Oomycota members are fungus-like protists. Although there have been several reports of various *Achlya* species infecting fish, there is no persistent and routinely reported clinical disease like Saprolegnia. Branchiomycosis, or gill rot, is a parasite of fish gill tissue. Fungal infection also occurs in shellfish like crab, lobster, and shrimp. However, frequent illnesses and epi zoonosis are considered one of the main production bottlenecks. The disease is thought to contribute 10-50% of the cost of production. The most prevalent disease affecting temperate fish is fungal infection (also known as mycosis). The growth of fish disease is posing new obstacles and causing economic losses, particularly as fish mortality rises.

Keywords: Fungal disease, aquaculture, economic loss, shellfishes, molecular identification

Introduction
Aquaculture has grown substantially over the last two decades and provides the most affordable protein source to the rapidly growing population around the world. The package of practices for aquaculture has transformed enormously and a paradigm shift is witnessed during the last two decades in terms of the incorporation of various technologies. India is primarily known for its carp farming, and it has the presence of Indian Major Carps (IMC), which include rohu (*Labeo rohita*), Catla (*Catla catla*), mrigal (*Cirrhinus mrigal*), exotic carps such as common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmicthys molitrix*) along with catfishes (*Clarius batrachus*, *Heteropneuestes fossilis*, *Pangassius* spp.) [35]. The extensively cultivated *Macrobrachium rosenbergii* likewise produces the majority of aquaculture production. Culturing pacu, *Piaractus brachypomus*, and the exotic catfish *Pangasiandon hypophthalamus* have grown recently [10]. The present ability in aquaculture development is towards intensification of cultural practices because there are fewer opportunities for horizontal expansion [7]. However, frequent illnesses and epi zoonosis are considered one of the main production bottlenecks. The disease is thought to contribute 10-50% of the cost of production [3]. Fungi and viruses have little impact on Indian aquaculture practises, and the infections are primarily of bacterial and parasitic origin [21]. The most prevalent disease affecting temperate fish is a fungal infection (also known as mycosis) [36]; because fungal spores are present in all fish ponds and pose issues in stressed fish, the fish population may experience more fungal diseases due to poor water quality [4]. Most fungi affect the exterior tissues, but very few fungi can infect the fish's internal organs [6]. A fungus of the genus Lagenidium was discovered in laboratory-rearing methods for American lobster (*Homarus americanus*) larvae [17]. The eventual mortality rate was greater than 90% when the fungus was identified in the first and second phases. Larval lobsters in their sixth and seventh stages appear to be immune to this infestation. The preliminary conclusion is that this fungus is the causative agent of a new larval lobster mycosis [32].

Fungal disease in the case of Fishes and Shellfishes
1. Cotton wool fungus (Saprolegniasis)
It is the most common mould infection, characterised by a thin, cotton-like growth on the skin or gills. These lesions frequently start out as tiny, localised infections that have the potential to spread quickly across the body surface [32]. Saprolegnia is an opportunistic fungal pathogen

mainly found in freshwater aquariums. Eventually, Lesions are white and turn red, brown, or green. The typical saprolegniosis lesions grow on the skin surface and typically do not penetrate inside into muscles [3]. The severity of the sickness is based on the extent of the skin and gill damage. Saprolegniasis typically develops as a secondary infection following fish integument damage [38]. Other risk factors, such as overcrowding and water pollution, also act as a reason for the occurrence of this disease. Symptoms include grey or white patches on the skin or gills, which may subsequently turn brown/green due to sediment trapping. [9]. Healthy fish can often stave off infection, while Saprolegnia preys on ill or damaged fish, causing secondary infections [24]. Untreated, Saprolegnia infections can be deadly [23]. The easiest strategy to avoid Saprolegnia is to keep your fish's water clean and offer them a nutritious diet that promotes their natural immune function [37]. Maintain your maintenance schedule, hoover debris from the gravel and keep a hospital tank ready to confine any potentially ill individuals [3]. Saprolegniosis may also occur in sea bream due to the low salinity of the brackish water [25]. A malfunctioning heater can cause temperature irregularity and potentially drastic drops in temperature that can encourage Saprolegnia. *S. parasitica*, a fish disease, is characterised by the presence of long-haired hook-like bundles. In conjunction with the sticky extracellular matrix and proteins (fibronectin and thrombospondin), these hooks improve cyst attachment to hosts [24].

2. Branchiomycosis

Branchiomyces sanguinis, which affects carp, and *Branchiomyces demigrans*, which affects pike and tench, are the two fungi that produce "Gill Rot" Disease. Both types of fungi are found in fish that are stressed by environmental factors such as low pH (5.8 to 6.5), low dissolved oxygen, or a heavy algal bloom. Although they thrive between 77° and 90°F, *Branchiomyces* species can grow at temperatures as high as 95°F. The primary sources of infection are debris on pond bottoms and fungal spores present in the water [10]. They infect fish's gill tissue. Fish may appear sluggish and piping (or gulping) air at the water's surface [40]. The paler regions of the gills indicate sick and dying tissue and seem striated or marbled. Fungal disease like *Branchiomyces demigrans* was recorded from farmed Nile tilapia in Behaira, Egypt [23]. Massive mortality, gill tissue destruction, and fast migration of the gill operculum were all seen in infected fish [39]. The fungus enters the gill via branchial arteries or the epithelium and can wreak havoc on respiratory surfaces. In Israel, a Branchiomyces-like fungus sp. was isolated from red tilapia (*O. niloticus* x *O. mossambicus*) and green tilapia (*O. niloticus* x *O. aureus*). The severe illness caused the death of 85% of the fish. Another pathogenic species, B. demigrans, was discovered from farmed Nile tilapia and common carp in several aquaculture regions in Egypt [23].

3. Icthyophonus

The Icthyophonus hoferi causes this disease. It can flourish only in cool temperatures (36° to 68°F) and grow in fresh saltwater and wild and farmed fish [41]. The disease is spread via cannibalism of sick fish and by the discharge of fungal cysts in excreta [40]. Ichthyophonus is a genus of unicellular eukaryotic fish parasites. They were formerly thought to be fungus, but phylogenetic data reveals they are protists linked to fungi and animals [33]. Fish with a mild to moderate infection will not exhibit any visible symptoms of the illness because the main method of transmission is through the consumption of infectious spores [10]. In severe cases, infection under the skin and muscle tissue can result in a "sandpaper texture" on the skin. Some fish have curved spines. Internal organs may be enlarged and covered with white to grey-white lesions [4].

4. Exophiala sp.

It Includes *Exophiala salmonis* and *E. psychrophila*; these fungi contain septated, asymmetrical, and branching hyphae [7]. Different types of fish were affected by these fungi [28]. Fish get darker and drowsier and swim erratically and abnormally [16, 17]. A systemic problem Exophiala-like mycosis occurred naturally in five captive fish genera, and it was created experimentally in three more genera: Tautogolabrus adspersus (Walbaum), Pseudopleuronectes americanus (Walbaum), and *Fundulus heteroclitus* (L.) via intraperitoneal injection of spores. Exophiala psychrophila sp. was isolated from infected Atlantic salmon smolt [29]. Morphological and physiological parameters distinguish it from other Exophiala species [30].

5. Larval Mycosis

This disease is caused by *Lagenidium* spp., *Sirolpidium* spp and *Haliphthoros* spp. This results in sudden mortalities of prawn and crab larvae [40]. Eggs of crabs are similarly prone to mycotic infection. The protozoal and mysis stages are the larval stages most frequently impacted in prawn species [16]. When aeration or circulation is limited, infected larvae become immobile and sink to the bottom of the tank; a substantial volume of the mycelial network is present, and it can be seen through the exoskeleton of dead and moribund larvae [6]. A primary mycosis of larvae was also observed in white shrimp, *Penaeus setiferus*, this disease first occurred in larvae during the second protozoeal stage and vanished when the prawns reached the first mysis stage [18].

6. Black Gill Disease

Black gill disease **is** an infection of decapods, caused primarily by Ascomycota. *Fusarium solani* caused black gill disease in Penaeus species [15]. The emergence of "black spots" that preceded mortalities in juvenile pond-raised prawns. Usually, an infection begins on tissues that have already been injured, such as wounds, gills that have been harmed by chemicals or other pollutants, or lesions brought on by other disease processes [5]. Once an infection has taken hold, it normally progresses with 30% chance of remission. Lesions may also act as a point of entry for other opportunistic diseases. Black gill illness has been detected in fish, crabs and prawns along human-populated coastlines on four continents [13]. A histology investigation of the shrimp control group and diseased groups was carried out by scientists from each region. The findings demonstrate that black gill illness is ubiquitous in all bodies of water [12]. In 2020, Chinese shrimp farms undertook genetic testing on diseased specimens in search of prevention techniques against high shrimp mortality rates, ultimately determining *Fusarium solani* as the reason [14]. The testing results showed that diseased prawns died at a rate of 88.66%. The University of Georgia's investigation into the aetiology of black gill illness in the United States Southeast Coast resulted in the first-ever sequencing of the rRNA (18S rRNA) gene (1634 bp) from a putative Hyalophysa chattoni ciliate-related strain. The sequence was submitted to the Genbank database [11]. Changes

in temperature and seawater have been identified as potential sources of parasite families, including ciliates. It is possible to prevent black gill illness in a regulated environment [15]. Morphological and genetic analyses were used to identify the causative agent of black gill disease in *Pontastacus leptodactylus* specimens obtained from six lakes. Fungi were recovered from crayfish tissues exhibiting indications of black gill disease [31].

7. Aflatoxicosis (Red Disease)

This is caused by aflatoxin, which is generated by Aspergillus flavus and other Aspergillus spp. and is a common contamination of incorrectly stored or expired food. Penaeus monodon and other Penaeus species are affected by these species [19]. It's also called Red Disease. Juvenile pond-cultured prawns exhibit yellowish, and later reddish, staining of their bodies and appendages [20]. Affected species exhibit poor swimming activity and become drowsy close to pond dikes [33]. Additionally, soft shelling is noticeable [8].

Conclusion

Various diseases are affecting fish present in various bodies. In our article, we have discussed the fungal disease. So, we have to develop precautionary measures to protect against disease occurrence in fish by means of various procedures. Fungal infections are typically indicators of a more serious problem. Saprolegniasis is a common fungal infection that affects the outer coats of fish. It is readily removed after the underlying cause of the illness has been discovered and corrected. The growth of fish disease is posing new obstacles and causing economic losses, particularly as fish mortality rises. The best control for all fungal infections is good management: good water quality, good nutrition and proper handling.

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