



Aquatic fungi of Iraq: A review

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Abstract

In this review the past and updated contributions on aquatic fungi in Iraq are provided. Up to date, 29 species of freshwater fungi (water molds) belong to the order Saprolegniales (Oomycota) were recorded and represented by four genera namely; *Achlya*, (11 species), *Dictyuchus* (6 species), *Calyptrolegnia* (2 species) and *Saprolegnia* (10 species) and two species of *Olpidium* (Chytridiomycota). These fungi were isolated mainly from waters of Shatt Al-Arab River and its creeks in Basrah. While 33 species of marine fungi have been recorded and isolated from various submerged wood and dead plants in saline and freshwater of southern Iraq. Literatures concerning the ecological investigations on aquatic fungi in this region were also cited in this review.

Key words: Aquatic fungi, ecology, freshwater fungi, marine fungi, taxonomy

1- Introduction

Aquatic fungi (water molds) represent a unique group of mycota that are well adapted to thrive in fresh aquatic environments (Johnson and Sparrow, 1962; Dick, 1973). Majority of freshwater fungi are belonging to the class Oomycetes. On the other hand, marine fungi are adapted to live in saline waters and they are mainly

belonged to Ascomycetes and Basidiomycetes (Kohlmeyer and Kohlmeyer, 1979). Ecologically, these fungi are widely distributed in different water bodies including lakes, rivers, pond, estuaries, seas and oceans over the world (Jones, 1976; Johnson et al., 2004). They play a major role in biodegradation in aquatic habitats and some species causing fish diseases and

others causing plant diseases (Kohlmeyer and Kohlmeyer, 1979; Alexopoulos, 1996). A controversial taxonomic disposition of freshwater fungi is in debate and traditionally are filed under the division Oomycota based on their morphological characters (Alexopoulos *et al.*, 1996), however, recently based on the phylogenetic approach this group of organisms has been transferred into the kingdom Chromalveolata (Phylum Straminipila) (Keeling *et al.*, 2005; Webster and Weber, 2007; Weber (2009). So by now, water molds are not considered within the kingdom of fungi. Nonetheless, the traditional classification system is still valid and used by mycologists in teaching and researches. The main characteristics features of water molds are; 1. Hyphae are coenocytic (no septa) 2. Cell-wall mainly composed of cellulose 3. Flagellated spores (zoospores) produced inside zoosporangia and 4. Sexual reproduction by means of oogonia and antheridia.

The pioneer work was carried out by Coker (1923) who gave a fundamental taxonomic concept of saprolegnoid fungi, however, noteworthy contributions lately have been made by many other researchers but the most extensive works has been conducted by Johnson (1953) and Seymour (1970). Recently a worth published book by Johnson *et al.* (2004) was focused on the systematic and biology of water molds covered all the publications regarding these

fungi. In this review I would like to report the past and updated studies which have been conducted on the freshwater and marine fungi by listing all the species that are recorded in Iraq.

Methodology

Taxonomic study

Water samples are often collected from a selected study sites using sterilized bottles. Samples are usually taken from the subsurface water and immediately brought to the laboratory for fungal isolation. Nevertheless, isolation of aquatic fungi can be carried out in situ by using submerged baiting technique (use a mesh or tea-balls containing baits) (Muhsin, 1977). The most common technique used for isolation of aquatic fungi is the baiting technique (Johnson, 1953) by using selected natural substrates (baits) such as hemp-seeds, sesame seeds, insects, fruits, or any other parts of plant and animal substrates. Baits after being autoclaved are placed in Petri-dishes containing water samples collected from natural aquatic habitats and often amended with antibacterial such as chloramphenicol (250 ug/L) to prevent bacterial growth. Water samples with baits should be incubated at 18-20 C, fungal growth colonized baits can be observed in few days. Dissecting microscope is used to examine the fungal colony structures. Slides should be prepared by cutting a part of the

fungal mycelium using a sharp razor and place on a slide and stain with a drop of lactophenol. Identification of the isolated fungi is according to the available taxonomic keys (eg. for the identification of Saprolegniales, Johnson, 1953; Seymour, 1970; Johnson et al., 2004). Living cultures of the aquatic fungi can be made by using corn meal agar (CMA) in slant tubes (for more details see Muhsin, 1977). Description of species and illustrations (photos and camera-lucida drawings) are necessary.

Ecological study

Ecological studies of aquatic fungi can be carried out by researchers to elucidate the population dynamics, frequency, occurrence, diversity and seasonal variation of fungal assemblages inhabiting aquatic habitats. This will need an appropriate methodology and accuracy in sampling method including the locations for collecting water samples firstly will be chosen, volume of water samples must be determined, time of collection and number of baits per Petri-dish must be considered. On the other hand, the environmental factors including water temperature, pH, salinity, BOD, are the most important parameters to be correlated with the fungal population dynamics structures. Determination of each of the mentioned structure is according to (Muhsin, 1985; Muhsin, 1987; Muhsin and Daraj, 1993).

Freshwater and Marine fungi recorded from Iraq

Four species of the genus *Dictyuchus* have been isolated from Shatt Al-Arab River (Basrah, Iraq), description, illustrations and taxonomic key were provided (Rattan et al., 1978). Meantime, two species of the genus *Calyptralegnia* were also reported and their description was given (Rattan et al., 1978). This study revealed that *D. monosporus*, among other species, was the most abundant in aquatic habitat in Basrah over collecting period, while the members of *Calyptralegnia* occurred in spring and autumn only. Later on, a new species *C. basraensis* Muhsin was isolated and described by Muhsin (1984). However, there are only two species belonging to this genus were previously described elsewhere (Hohnk, 1953). On the other hand, five species of the genus *Saprolegnia* were recorded from Shatt Al-Arab waters (Ismail et al., 1979). *S. ferax* was the most common species in these waters. Within the genus *Achlya*, 11 species were isolated from the same location, a detailed description, illustrations and a proposed key for these species were provided (Muhsin et al., 1984). More aquatic fungal species including five species of *Saprolegnia* and two species of *Achlya* were isolated and newly recorded from Iraq (Muhsin and El-Habeeb, 1999). Only two

species of *Olpidium* were recorded by Abdullah et al. (2003). Recently, a survey on water molds in Shatt Al-Arab River indicated that the members of Saprolegnoid fungi were significantly declined in their frequency and dominance (Muhsin et al., 2011) as compared with a previous study by Muhsin (1977). This may explain that changing in the ecological factors of the aquatic environment in these waters may be due to the increase of water salinity levels (from 0.7 in the year 1977 to 2.7 ‰ in 2010). It has been also observed that there is an inverse correlation between the numbers of Saprolegnoid fungi and phytoplankton numbers in Shatt Al-Arab waters (Al-Saadi et al., 1979). Seasonal periodicity of Saprolegnoid fungi has been studied (Rattan et al., 1980), a maximum occurrence of these fungi was in winter and minimum in summer. This fluctuation pattern was attributed to the temperature as a major factor affecting the growth and reproduction of aquatic fungi. From the ecological point of view, aquatic fungi represented by the species of Saprolegniales are known as fresh water fungi.

It is worth mentioning that some marine fungal species were became inhabitant in Shatt Al-Arab waters. Abdulkadir and Muhsin (1991) reported 11 marine species

from submerged plants in these waters. More marine fungal species have been also isolated from submerged wood in various water bodies in Basrah and ten species were recorded (Muhsin and Khalaf, 2002). Also, Abdullah and Abdulkadir (1987) reported some freshwater and marine species from southern marshes of Iraq. A new marine species has been designated from marsh habitat by Abdullah et al. (1989). In addition, two new species *Arxiomyces zubairiensis* (Abdullah and Al-Sadoon (1994 b) and *Sypastospira tetraspora* (Abdullah and Al-Sadoon, 1994 a) were isolated from decaying culms of *Phragmites* and *Arundo* submerged in waters of Khawr Al-Zubair estuary. Some ascomycetous marine fungi have been also reported as new species (Guarro et al., 1996; 1997a,b; Al-Saadoon et al., 2001; 2006;).

More aquatic fungal species have been isolated from water bodies in Basrah, however, no taxonomic description has been given, these including; *Aphanomyces laevis*, *Aqualiderella* sp., *Calyptelegnia achlyoides*, *Leptolegnia* sp., *Pythium debaryanum*, *Saprolegnia turfosa* and unidentified taxon (Muhsin et al., 1993). All of the recorded species of freshwater fungi (Table 1) and marine fungi (Table 2) from Iraq are listed in this review.

Table1. Aquatic fungi recoded from Shatt Al-Arab River in Basrah, Iraq (for details on the taxonomic description, illustration and key of fungal species see the references listed in the tables)

Fungal species	References
Oomycota	
<i>Achlya ambisexualis</i> Raper	Muhsin <i>et al.</i> (1984)
<i>A. debaryana</i> Humphery	Muhsin <i>et al.</i> (1984)
<i>A. dubia</i> Coker	Muhsin <i>et al.</i> (1984)
<i>A. klebsiana</i> Pieters	Muhsin <i>et al.</i> (1984)
<i>A. oblongata</i> var. <i>gigantica</i> Forbes	Muhsin <i>et al.</i> (1984)
<i>A. polyandra</i> Hildbrand	Muhsin <i>et al.</i> (1984)
<i>A. Prolifera</i> Nees	Muhsin <i>et al.</i> (1984)
<i>A. Proliferoides</i> Coker	Muhsin <i>et al.</i> (1984)
<i>A. racemosa</i> Hildbrand	Muhsin <i>et al.</i> (1984)
<i>A. treleaseana</i> (Humphery) Kaufmann	Muhsin <i>et al.</i> (1984)
<i>A. aff. caroliniana</i> Coker	Muhsin <i>et al.</i> (1984)
<i>Dictyuchus achlyoides</i> (Coker & Couch) Coker	Rattan <i>et al.</i> (1978)
<i>D. carpophorous</i> Zopf	Rattan <i>et al.</i> (1978)
<i>D. magnusii</i> Lindst.	Muhsin (1977)
<i>D. monosporus</i> Leitgeb	Rattan <i>et al.</i> (1978)
<i>D. pseudodictyon</i> Coker & Brakston	Muhsin (1977)
<i>D. pseudoachlyoides</i> Beneke	Rattan <i>et al.</i> (1978)
<i>Calyptralegnia basraensis</i> Muhsin	Muhsin (1994)
<i>C. ripariensis</i> Hohnk	Rattan <i>et al.</i> (1978)
<i>Saprolegnia anisospora</i> de Bary	Ismail <i>et al.</i> (1979)
<i>S. australis</i> Elliot	Muhsin & El-Habeeb (1999)
<i>S. declina</i> Humphery	Ismail <i>et al.</i> (1979)
<i>S. delica</i> Coker	Muhsin & El-Habeeb (1999)
<i>S. ferax</i> (Gruith) Thuret	Ismail <i>et al.</i> (1979)
<i>S. hypogyna</i> (Pringsheim) de Bary	Muhsin & El-Habeeb (1999)
<i>S. litoralis</i> Coker	Muhsin & El-Habeeb (1999)
<i>S. parasitica</i> Coker	Ismail <i>et al.</i> (1979)
<i>S. terrestris</i> Cookson ex Seymour	Ismail <i>et al.</i> (1979)
<i>S. uliginosa</i> Johannes	Muhsin & El-Habeeb (1999)
Chytridiomycota	
<i>Olpidium bornovanus</i> (Sahityama) Karling	Abdullah <i>et al.</i> (2003)
<i>Olpidium brassicae</i> (Wor.) Dang	Abdullah <i>et al.</i> (2003)

Table 2. Marine fungi recorded from different saline aquatic habitats in Basrah, Iraq

Fungal species	References
<i>Arxiomyces zubairiensis</i> Abdullah & Al-Saadon	Abdullah & Al-Saadon (1994b)
<i>Aniptodera chesepeakensis</i> Shearer & Miller	Abdullah & Abdulkadder (1987)
<i>A. mauritanicensis</i> Hyde, Ho & Tsu	Al-Saadon & Abdullah (2001)
<i>A. palmicola</i> Hyde, Ho & Tsu	Al-Saadon & Abdullah (2001)
<i>Basramyces marinus</i> Abdullah, Abdulkadir & Goos	Abdullah <i>et al.</i> (1989)
<i>Camarosporium roumeguerii</i> Saccardo	Abdulkadir & Muhsin (1991)
<i>Cirrenalia macrocephala</i> (Kohlm.) Meyers et Moore	Abdulkadir & Muhsin (1991)
<i>Clavatospora bulbosa</i> (Anastas.) Nakagi. et Tubaki	Muhsin & Khalaf (2002)
<i>Coniothyrium obiones</i> Jaap	Abdulkadir & Muhsin (1991)
<i>Corollospora maritima</i> Werdermann	Abdulkadir & Muhsin (1991)
<i>C. mesopotamica</i> Al-Saadon	Al-Saadon (2006)
<i>Didymosphaeria enalia</i> Kohlm	Abdulkadir & Muhsin (1991)
<i>D. futilis</i> (Berk & Br.) Rehn.	Abdullah & Abdulkadder (1987)
<i>Leptosphaeria albopunctata</i> (Westendorp) Saccardo	Abdullah & Abdulkadder (1987)
<i>L. oremaris</i> Linder	Abdullah & Abdulkadder (1987)
<i>Lulworthia grandispora</i> Meyers	Muhsin & Khalaf (2002)
<i>L. medusa</i> (Ellis et Everh) Cribb et Cribb	Muhsin & Khalaf (2002)
<i>Mycosphaerella neumatoxora</i> Kohlm.	Muhsin & Khalaf (2002)
<i>Nais inornata</i> Kohlm.	Muhsin & Khalaf (2002)
<i>Ophiobolus australiensis</i> Johnson & Sparrow	Abdulkadir & Muhsin (1991)
<i>Periconia prolifera</i> Anastas	Muhsin & Khalaf (2002)
<i>Pleospora gaudefroyi</i> Patouillard	Abdulkadir & Muhsin (1991)
<i>P. herbarum</i> (Fr.) Rabenh.	Abdullah & Abdulkadder (1987)
<i>Preusia dispersa</i> (Clun) Cain	Abdullah & Abdulkadder (1987)
<i>Preussia aquilirostrata</i> Guarro, Abdullah, Gene & Al-Saadon	Guarro <i>et al.</i> (1997 b)
<i>Pseudoallescheria desertorum</i> (Arx et Mustafa) McGinnis	Muhsin & Khalaf (2002)
<i>Pyrenophora tyaecola</i> (Cke.) Mull.	Abdullah & Abdulkadder (1987)
<i>Savoryella lignicola</i> Jones & Eaton	Al-Saadon & Abdullah (2001)
<i>Sphaerulina oraemaris</i> Linder	Muhsin & Khalaf (2002)
<i>Sypastospora tetraspora</i> Abdullah & Al-Saadon	Abdullah & Al-Saadon (1994a)
<i>Trichocaldium linderi</i> Crane & Shearer	Abdulkadir & Muhsin (1991)
<i>Zalerion varium</i> Anastas.	Abdulkadir & Muhsin (1991)
<i>Zopfiella submerse</i> Guarro, Al-Saadon, Gene & Abdullah	Guarro <i>et al.</i> (1997a)

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الخلاصة

تناول هذا الاستعراض الفطريات المائية المسجلة في العراق وقد تبين وجود 29 نوعاً من فطريات المياه العذبة والتي تعود الى الرتبة Saprolegniales متمثلة باربعة اجناس هي: *Achlya* (11 نوع) و *Dictyuchuse* (6 انواع) و *Calyptralegnia* (نوعين) و *Saprolegnia* (10 انواع) وهذه كلها عزلت من مياه شط العرب وفروعه في البصرة. كما تبين وجود 20 نوعاً من الفطريات البحرية المعزولة من الاخشاب والمواد النباتية الميتة الموجودة في المياه المالحة في جنوب العراق.