

Aquatic fungi from Egyptian soils (Upper Egypt)

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Some aquatic fungi (*Achlya americana*, *Dictyuchus sterile*, *Saprolegnia parasitica*, *Saprolegnia ferax*, *Pythium* spp. and *Allomyces arbuscula*) were isolated from water, mud and soil samples. Some others (*Achlya megasperma*, *S. oblongata*, *Dictyuchus monosporus* and *Saprolegnia monoica*) were recovered from water and mud samples only. Only two species (*Saprolegnia furcata* and *Pythium intermedium*) were isolated from both soil and mud samples. *Achlya polyandra* was recorded from mud samples only. Twenty species were recovered from soil samples only.

Numerous studies were conducted in various geographical regions of the world concerning the aquatic fungi and their relation to water habitat. EL-NAGDY (1985) working on aquatic fungi recovered from the various water habitats in Upper Egypt, gave a detailed survey of literature concerning the aquatic fungi isolated from different geographical regions of the world.

As for the aquatic fungi recovered from soil habitats, some studies were also carried out in the United Kingdom (IVIMEY-COOK & MORGAN, 1934; WILLOUGHBY, 1961; DICK, 1962); in Scandinavia (JOHNSON, 1977); in Denmark (LUND, 1978); in U.S.A. (SCHMITT & BENEKE, 1962; STANGHELLINI & al., 1983); in Japan (SUZUKI, 1961; CHIEN, 1974); in Australia (JEFFREY & WILLOUGHBY, 1964); in New Zealand (KARLING 1965, 1968); in India (KRISHNA & MEHROTRA, 1977; CHOWDHERY & RAI, 1980; SATI & KHULBE, 1980; MER & al., 1981; RAO & VENKATESWARLU, 1983); in Nigeria (ALABI 1967, 1971, 1974; FAJOLA & al., 1978).

In Egypt, attention was recently given to the study of aquatic fungi in various water and soil habitats. EL-HISSY (1979 a,b,c) and EL-HISSY & EL-NAGDY (1983) working on the river Nile mud, near Assiut, and KHALIL (1984) studied the aquatic fungi in the water and mud of the biggest irrigation canal in Egypt (Ibrahimia canal).

The present investigation aimed to study the occurrence and distribution of aquatic phycomycetes in Egyptian soil in Upper Egypt from Aswan to El-Giza. Soil samples were collected to study the aquatic fungal population and distribution in relation to some soil characteristics. Since the river Nile represents the main source for irrigation water in Egypt, the aquatic fungal population in the soil could be influenced by the fungal population in the Nile water.

Therefore, a comparison between the aquatic fungal flora isolated from the investigated soil samples and that isolated from the river Nile water and mud near Sohag (475 Kilometers south of Cairo and about 400 Kilometers north of Aswan) was done during the period of this investigation.

Materials and Methods

315 soil samples were collected at seven sites in Upper Egypt from Aswan to El-Giza including El-Fayoum Governorate. These samples were collected from cultivated and non-cultivated soils in addition to muddy soils forming the banks of small ponds and irrigation canals, and brought to the laboratory in clean plastic bags (containing 500 gms each). The maximum period required to bring the samples from the field to the laboratory was 24 hrs. In addition, water and mud samples were collected from the river Nile near Sohag monthly from September 1982 to March 1984.

The temperature and the pH value of the soil, mud and water samples were measured at the time of sampling. The water content of the soil and mud samples, the total soluble salts and the organic matter content of all samples (soil, mud and water) were determined.

Baiting of soil samples: For the recovery of the aquatic fungi from soil or mud samples, 5 gms of each sample were introduced into a sterile, clean, 12 cm Petri-dish (6 replicates). The soil in each Petri-dish was then covered with sterile distilled water (20 ml) and three sterilized hemp and sesame seeds were introduced into each dish according to KHALIL (1984). For the recovery of Chytridiales, another Petri-dish was baited by adding dry *Pinus* pollen grains instead of hemp- and sesame seeds. The dishes were incubated at room temperature for about 24 hours and the colonized seeds and grains were then transferred to sterile distilled water in Petri-dishes which contained crystalline penicillin (2000 i.u./L) to depress bacterial growth (ROBERTS, 1963). The dishes were then incubated at 22 °C for about 4–6 weeks during which the aquatic fungi colonizing the seeds and grains were examined weekly. After each examination, the colonized seeds and grains were again transferred into clean sterile Petri-dishes containing sterile distilled water.

For the recovery of aquatic fungi from the Nile water, 50 ml of each water sample were introduced into a sterile 12 cm Petri-dish (6 replicates). Three sterilized hemp- and sesame seeds were introduced into each Petri-dish. Another dish was baited with *Pinus* pollen grains. The dishes were then treated as mentioned above.

The aquatic fungi recovered from soil, mud and water samples were purified on glucose-peptone (Gp) agar medium (WILLOUGHBY & PICKERING, 1977).

The identification of aquatic fungal genera and species was performed after COKER (1923), FITZPATRICK (1930), JOHNSON (1956), SPARROW (1960), SCOTT (1961), WATERHOUSE (1967), KARLING (1968), SEYMOUR (1970), JOHNSON (1971), KARLING (1977), RATTAN et al. (1978), ISMAIL & al. (1979), KHULBE (1980 a, b) and GOLUBIVA (1982).

The results were analysed by analysis of variance procedures; the least significant differences were computed as given by SNEDECOR & COCHRANE (1967).

Results and Discussion

The soil samples collected during this investigation could be grouped into four types according to their texture and water content: Sandy (14 samples), wet-sandy (49 samples), sandy-clay (48 samples) and clay (204 samples).

Thirty-seven species of aquatic fungi which belong to 16 fungal genera were collected during this investigation (Tab. 1).

The texture of soil may represent a factor which directly or indirectly affects the fungal population and occurrence. The sandy soil samples (14) were relatively poor (average number of species 1.85/sample) in aquatic fungi. The most frequent species in this type were *Anisolpidium saprobium* (chytrids, 10 samples), *Allomyces arbuscula* (8 samples) and an unidentified *Pythium* species (3 samples). *Achlya americana*, *Saprolegnia parasitica*, *Pythium intermedium*, *Achlya racemosa* and *Allomyces javanicus* were also isolated only once from one sample each.

The wet sandy soil samples (49) contained a mean value of 1.8 species per sample. Following species were isolated (Tab. 1): *Anisolpidium saprobium* (19 samples), *Pythium* species (17 samples), *Allomyces arbuscula* (16 samples), *Dictyuchus sterile* (13 samples), *Achlya americana* (5 samples), *Saprolegnia ferax* and *S. parasitica* (4 samples each), *Allomyces javanicus* and *Pythium intermedium* (2 samples each). *Achlya racemosa*, *A. megasperma*, *Achlya* sp. *Allomyces macrogynus*, *Saprolegnia anisospora*, *Dictyuchus polysporus* and *Leptomitius lacteus* were recovered from one soil sample each.

The sandy clay soil samples (48) yielded 1.9 species per sample on the average. *Allomyces arbuscula*, *Anisolpidium saprobium* and *Pythium* sp. (29, 28 and 22 samples respectively) as well as *Saprolegnia ferax* and *S. parasitica* (2 samples each) were the most frequently isolated species. *Achlya americana*, *Allomyces anomalus*, *A. javanicus*, *Dictyuchus sterile*, *Pythium intermedium*, *P. oligandrum*, *Oedogoniomyces* sp. and *Septochytrium variabile* were collected from one sample each (Tab. 1).

The clay soil samples (204) yielded an average number of species

Tab. 1: List of aquatic fungi recovered from the soil, Nile water and mud samples, and number of isolations for each fungus. (in brackets: no. of samples).

Taxa	SOIL TYPES				Nile samples	
	Sandy (14)	Wet sandy (49)	Sandy-clay (48)	Clay (204)	Water (18)	Mud (18)
	No. of isolations					
<i>Achyla</i>						
<i>A. americana</i> * HUMPHRY	1	5	1	8	2	2
<i>A. dubia</i> * COKER	-	-	-	-	1	-
<i>A. hypogyna</i> COKER & PREMBERTON	-	-	-	-	-	-
<i>A. klebsiana</i> * PETERS	1	5	1	8	2	2
<i>A. megasperma</i> HUMPHRY	-	-	-	-	1	1
<i>A. oblongata</i> DE BARY	-	-	-	-	1	1
<i>A. polyandra</i> HILDEBRAND	-	-	-	-	-	1
<i>A. racemosa</i> * HILDEBRAND	1	1	-	-	-	-
<i>Achyla</i> sp.	-	1	6	9	-	-
<i>Allomyces</i>						
<i>A. arbuscula</i> BUTLER	8	16	29	97	3	5
<i>A. macrogynus</i> * (EMERSON) EMERSON & WILSON	-	1	-	7	-	-
<i>A. javanicus</i> * (KNIEP) EMERSON & WILSON	1	2	1	6	-	-
<i>A. anomalus</i> * EMERSON	-	-	1	10	-	-
<i>Aphanomyces</i>						
<i>A. laevis</i> * DE BARY	-	-	-	-	-	-
<i>Dictyuchus</i>						
<i>D. polysporus</i> * LENDSTEDT	-	1	-	-	-	-
<i>D. monosporus</i> LEITGE	-	-	-	-	2	2
<i>D. sterile</i> * COKER	-	13	1	19	7	8
<i>Isoachlya</i>						
<i>I. monilifera</i> (DE BARY) KAUFFMANN	-	-	-	1	-	-
<i>Leptomitius</i>						
<i>L. lacteus</i> * (ROTH) AGARDH	-	1	-	-	-	-
<i>Olpidiopsis</i>						
<i>O. saprolegniae</i> * COKER	-	-	-	1	-	-
<i>Phytium</i>						
<i>P. aquatile</i> * HÖHNK	-	-	-	1	-	-
<i>P. cactacearum</i> * PERTI	-	-	-	1	-	-
<i>P. oligandrum</i> * (DRECHSLER)	-	-	1	-	-	-
<i>P. papillatum</i> * MATTHEWS	-	-	-	1	-	-
<i>P. intermedium</i> * DE BARY	1	2	1	7	-	1
<i>Phytium</i> sp.	3	17	22	101	4	5

* = Aquatic phycomycetes recorded for the first time in Egyptian soil.

Tab. 1 (cont.)

Taxa	SOIL TYPES				Nile samples	
	Sandy (14)	Wet sandy (49)	Sandy-clay (48)	Clay (204)	Water (18)	Mud (18)
	No. of isolations					
<i>Saprolegnia</i>						
<i>S. anisospora</i> DE BARY	–	1	–	–	–	–
<i>S. ferax</i> * (GRUTH) THURET	–	4	2	9	9	8
<i>S. monoica</i> * TIESENHAUSEN	–	–	–	–	1	1
<i>S. parasitica</i> * COKER	1	4	2	4	3	2
<i>S. furcata</i> MAURIZIO	–	–	–	1	–	1
<i>Sapromyces</i>						
<i>S. reinschii</i> * (SCHROET) FRITSCH	–	–	–	1	–	–
<i>Pilobolus</i>						
<i>P. crystallinus</i> (WIGGERS) TODE	–	–	–	–	–	1
<i>Mastigochytrium</i>						
<i>M. sacardiae</i> * LAGERHEIM	–	–	–	1	–	–
<i>Septochytrium</i>						
<i>S. variable</i> * HERDAN	–	–	1	–	–	–
<i>Oedogoniomyces</i> sp.	–	–	1	–	–	–
<i>Anisolpidium</i>						
<i>A. saprobium</i> KARLING	10	19	28	129	–2	–
<i>Catenaria</i>						
<i>C. allomyces</i> * COUCH	–	–	–	1	–	–
<i>Brachyallomyces</i> sp.	–	–	–	1	–	–

* = Aquatic phycomycetes recorded for the first time in Egyptian soil.

of 2.1 per sample. The most frequent were *Anisolpidium saprobium*, *Allomyces arbuscula* and *Dictyuchus sterile* (129, 97 and 19 samples respectively; Tab. 1).

With respect to the various Governorates from which the soil samples were collected, soil samples from Beni-Swif were the richest in aquatic fungal genera and species (8 genera and 13 species), Qena came second (7 genera and 15 species), Sohag and El-Giza gave approximately the same number of aquatic fungal genera and species (7 genera each, 11 and 10 species respectively). El-Minya soil samples were the poorest in fungal genera and species.

The soil temperature at the time of sampling ranged between 8.5–14 °C in the case of the samples richest in aquatic fungi (contributing 4–5 species) and between 15–38.5 °C in case of the samples contributing no species. Statistical analysis of the results reveals that the average temperature at the time of sampling was significantly higher for the poorest (30.8 °C) than for the richest samples

(23.6 °C). On the other hand, RAO & VENKATESWARLU (1983), in their study of the microbial ecology of soils in indian deserts, reported no significant decline in the population of microorganisms during summer, in spite of the high surface soil temperature, which sometimes may reach 50 °C. Similarly, FAHNH (1973), and TOMLINSON & WILLIAMS (1975) proposed a wide range of temperature (14–30 °C) for adequate fungal growth and reproduction, either in freshwater or in the soil.

The great majority of soil samples showed no appreciable differences in pH which ranged between 7.1–8.9. Very few samples showed extreme pH: five samples had a pH between 6–10 and 10 samples between 9.0–9.4. No significant differences in pH were observed between the richest (4–5 species) and the poorest samples, which means that the pH of soil has no clear effect on aquatic fungi in soil. In this respect, SUZUKI & NIMURA (1961 a, b) in Japan proposed a wide range of pH levels from 3–10 for fungal growth in water habitats. PAUL & al. (1984) in Mexico found that the pH value was no limiting factor for fungal development in waste stabilization pond system.

The water content of the soil samples varied between 1.9–7.5% (13 samples) and 61.8–66.8% (six samples). The remaining samples were intermediate between the previous values. Statistical analysis indicates that there was a significant difference between the average water content of the richest (25.65%) and the poorest sample (average 33.1%). Therefore, it can be concluded that the water content of the soil is one factor that affects the occurrence of aquatic fungi in the soils tested in this investigation. This result agrees with that obtained by EL-HISSY (1979 b) in Egypt. WILLOUGHBY (1961) concluded that the moisture content of the soil samples represents the main important factor in determining the occurrence of aquatic fungal flora in these samples. This is also in agreement with the results obtained by LUND (1978) in Denmark.

The content of total soluble salts seems to have no effect on the occurrence of aquatic fungi. It ranged between 0.1%–6% in case of the richest soil samples which contributed 4–5 species, and between 0.14–8% in case of the samples completely free from aquatic fungi. CHOWDHERY & RAI (1980) in India isolated aquatic fungi from mangrove swamps with high salinity, high moisture content and aerobic conditions.

The organic matter content in the test samples ranged between 0.05–1.27 g/100 g in the richest soil samples (4–5 species). There was a significant difference between the average content of organic matter in the richest (average 0.46%) and the poorest samples (0.66%). The richest soil samples in aquatic fungi have on the average a low content of organic matter.

Anisopoldium saprobium was the most frequent species isolated (186 soil samples). *Allomyces* came second in the order of frequency

(179 samples) and was represented by *A. arbuscula*, *A. anomalus*, *A. javanicus* and *A. macrogynus* (151, 11, 10 and 8 soil samples respectively). ALABI (1973) in Nigeria isolated *Allomyces arbuscula* and *A. moniliformis*. JEFFREY & WILLOUGHBY (1964) in Australia and CHIEN (1974) in Japan isolated *Allomyces* from a variety of soil groups. EL-HISSY (1979 b) isolated *Allomyces* from 5 out of 24 Egyptian soil samples.

Pythium was recovered from 159 soil samples. This genus was represented by 5 species. The most common species, present in 142 soil samples, could not be identified; *Pythium intermedium* emerged from 13 samples only. JOHNSON (1971) in Iceland identified 60 *Pythium* species from water and soil samples collected from various localities. KHULBE (1983) in India isolated *Pythium elongatum* from moist soil. EL-HISSY (1979 b) isolated two *Pythium* species from the casts and surfaces of earthworms and from the soil where the worms were collected. EL-SHAROUNY (1980) recovered seven species of *Pythium* from Egyptian soils with *P. irregulare* as the most common.

Achlya, *Dictyuchus* and *Saprolegnia* were recovered from 36, 34 and 29 soil samples, respectively. The first genus was represented by six species and an unidentified one.

Dictyuchus was represented by *D. sterile* and *D. polysporus*. *Saprolegnia* was represented by five species. FAJOLA & al. (1978) in Nigeria and LUND (1978) in Denmark isolated these genera from soil. CHOWDHERY & RAI (1980) described five species of aquatic Oomycetes from mangrove soil and RAI & MISRA (1977) isolated six species of *Achlya* and three species of *Saprolegnia* from alkaline ponds and soils in India. SATI & KHULBE (1980) isolated *Saprolegnia* and *Dictyuchus* from soil samples in India. EL-HISSY (1979 b) identified six species of *Achlya*, two species of *Saprolegnia* and one species of *Dictyuchus* from Egyptian soils.

Six genera were rare in the examined soil samples (1–4 samples) and each was represented by one species (Table 1). PERROTT (1960) isolated *Isoachlya monilifera*, *Aphanomyces laevis* and *Olpidiopsis saprolegniae* from a variety of freshwater habitats in the United Kingdom. KRISHNA & MEHROTRA (1977) recorded *Pilobolus* sp. and *Leptomitus* from India soils. Also, KARLING (1968) reported members of Olpidiopsidaceae in numerous soil samples in New Zealand. MILANEZ (1968) isolated *Saprolegnia diclina* and *Sapromyces androgynus* from the Cerrada region of Sao Paulo state in Brazil. EL-HISSY (1979 b) also isolated the same six species from Egyptian soils.

Some other genera of Chytridiales in addition to *Anisulpidium* were rarely isolated. These were *Catenaria allomycis*, *Mastigochytrium saccardiae*, *Oedogoniomyces* sp. *Septochytrium variabile* and *Brachyallomyces* (Table 1); each of these was recovered from one sample only.

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