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Dedicated to Professor Alina Skirgiełło
on the occasion of her ninety-fifth birthday

Biodiversity of zoosporic fungi in polluted water drainages across Niles´ Delta region, Lower Egypt

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Thirty-four identified in addition to five unidentified species appertaining to ten genera of zoosporic fungi were identified and isolated from eighty four polluted water samples, which were randomly collected from different polluted sites of the water drainages along the Niles Delta in Lower Egypt. Baiting sesame seeds culture technique was employed at 20±2°C for the recovery of zoosporic fungi. The genera; *Pythium* and *Saprolegnia* (8 and 7 zoosporic fungal species, respectively) showed the broadest spectra of species diversity whereas *Aqualinderella* was only represented by one species (*A. fermentans*). *Saprolegnia delica* and *Dictyuchus carpophorus* (the greatest fungal populations) were the most dominant isolated zoosporic fungal species where they were highly occurred especially at the hyper-polluted waters with the heavy metals. These two species could be considered as indicators for the response of the structure and function of microbial communities for water pollution. Several zoosporic fungal species were rarely encountered. Both *Aqualinderella fermentans* and *Pythium rostratum* were recovered in moderate frequency of occurrence. Water samples which had high concentrations in heavy metals were the poorest in the species diversity of zoosporic fungi. Despite that, fungal species belonging to the family *Saprolegniaceae* flourished in hyper polluted water samples whilst those belonging to the family *Pythiaceae* predominated in more diluted water samples. Also, the prevalent species; *S. delica* and *D. carpophorus* were not affected by heavy metals concentrations being as indicators for water pollution with the heavy metals. pH values of the polluted water samples had no influence on the occurrence of zoosporic fungi. Water samples characterized by high organic matter content and low total soluble salts were the richest in zoosporic fungal species.

Key words: zoosporic fungi, diversity, pollution, drainages

INTRODUCTION

Heavy metals pollution has increased over the last few decades through mining, industrial emissions and garbage disposal, and as by-products of agricultural fertilizers (Merian 1991). As a result pristine ecosystems are becoming scarce. The occurrence of several aquatic hyphomycete species in heavily polluted streams has been reported (Sridhar et al. 2000; Krauss et al. 2001; Luo et al. 2004; Pascoal et al. 2003, 2005).

In Egypt, several reports (El-Hissy, Khallil 1989; El-Hissy et al. 1982, 1992, 2004; Khallil et al. 1993) deal with the distribution and regional occurrence of zoosporic fungi recovered from River Nile and other water resources. As yet, little attention (El-Hissy et al. 2001) has been given for studying the biodiversity and occurrence of zoosporic fungi in polluted water especially at sites polluted by heavy metals. This investigation is an attempt to study the ecological biodiversity of zoosporic fungi from water drainages located in the Nile Delta region in Lower Egypt. We also consider the relationship between the fungal biodiversity and some ecological and chemical parameters of polluted water.

MATERIALS AND METHODS

Sampling sites and sampling procedure. Field studies were conducted during March 2006 in the Nile Delta region of Lower Egypt in El-Kalyobia, El-Monofeyia, El-Gharbia, Kafr El-Shekh, Damietta, El-Dakahlia and El-Sharkya (Fig. 1). Eighty-four polluted water samples (twelve sites from each governorate) were randomly collected from different drainages that represent the wastes of water irrigation of cultivated fields. Six 300 ml sterilized, glass bottles were used for each collecting site; five bottles contained sterilized, germinating sesame seeds as bait for zoosporic fungi and the six bottle was for collecting water for chemical analysis. Glass bottles that contained sesame seeds were aerated at different time intervals. Water sam-

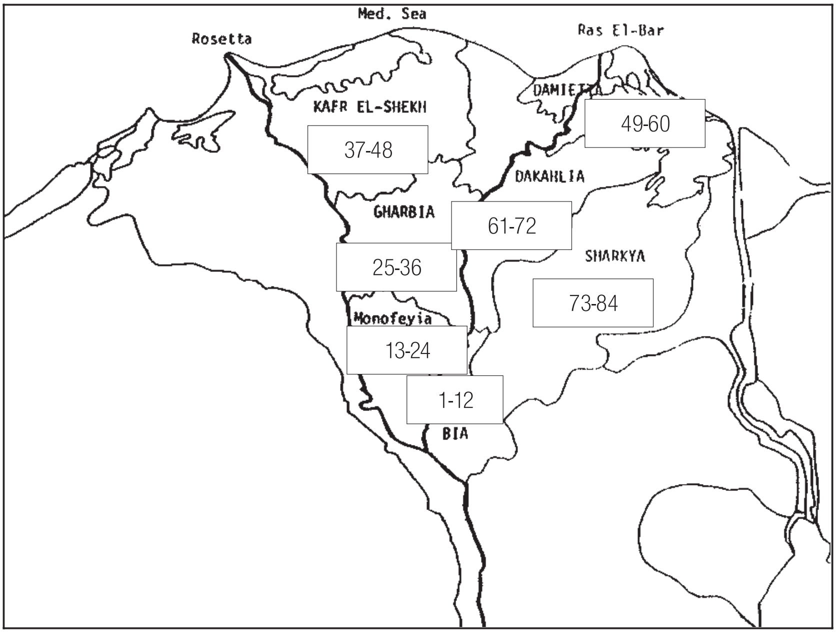

Fig. 1. The Nile Delta area from which polluted water samples of drainages were collected.

ples were brought directly to the laboratory for the recovery of zoosporic fungi and chemical analysis.

Physico-chemical analysis of polluted water samples. Physical characteristics of water samples such as water temperature and pH value were measured *in situ* with field probes (Thermometer and pH meter). Glass bottles containing water samples with no added sesame seeds (bottles no. 6) were used for the chemical analysis at each sampling site. The total soluble salts and organic matter contents were chemically estimated based on Jackson (1958). The heavy metals (Pb, Zn, Co, Cu and Cd) of polluted water samples were determined with an Atomic Absorption Spectrophotometer (*Varian*, Model AA 55).

Microbial analysis for baiting and recovery of zoosporic fungi. For baiting and recovery of zoosporic fungi, the polluted water samples containing the baits of sesame seeds were poured under aseptic conditions into Petri-dishes (15 cm in diameter). Petri-dishes (5 for each water sample) were transferred into an incubator at 20°C and left over night (24 hours) during the colonization of sesame seeds by fungal propagules (El-Hissy, Khallil 1989). Colonized sesame seeds were transferred into other equivalent, smaller Petri-dishes (10 cm in diameter each) to which crystalline penicillin (2000 units/ ml) was supplied for suppressing the bacterial growth (Roberts 1963). The dishes were then, again, incubated at 20°C for a period of twenty days during which they were examined daily for the identification of zoosporic taxa. Transferring colonized sesame seeds into new Petri dishes with sterilized distilled water refreshed growth of taxa of zoosporic fungi. Most of the Oomycetes were purified on glucose-peptone (GP) agar medium (Willoughby, Pickering 1977) whereas yeast-peptone starch medium (YpSs) was used for purification of *Allomyces* sp. (Emerson 1941), which belong to Chytridiomycetes. The fungal cultures were maintained on the previously mentioned media and stored at 8-12°C and sub-cultured every 2-3 months. The number of cases of isolation and occurrence remarks of each taxa (genera and species) of zoosporic fungi was calculated from the total number of the tested polluted water samples (84 water samples). They were designed as follows:

H= high occurrence; more than 42 samples out of 84 water samples
M= moderate occurrence; between 21-42 water samples
L= low occurrence; between 10-20 water samples
R= rare occurrence; less than 10 samples out of 84 water samples.

Regarding the determination of total counts of zoosporic fungal genera and species which were recovered during this study, the fungal species appeared on one dish was counted as one colony to the number of seeds (40 isolates) for each tested sample.

Identification of the genera and species of zoosporic fungi. The following references were adopted as syllabi for the morphological identification of the genera and species of zoosporic fungi during this study and they were as follows: Coker (1923), Johnson (1956, 1971, 1977), Waterhouse (1956, 1968), Sparrow (1960), Scott (1961), Seymour (1970), Karling (1977) and Natvig (1987).

Statistical analysis. Simple and multi-correlation statistical analysis was designed. This statistical analysis was functioned to test the effect of physicochemical characteristics of water samples versus the number of the recovered species of zoosporic fungi in each water sample.

RESULTS AND DISCUSSION

The pH values of the polluted water samples, which were collected from different water drainages located in Nile Delta region in Lower Egypt, were in the alkaline side and ranged between 8.36 and 11.15 (Tab. 1). The results of the simple and multiple correlation analysis showed that the pH value had no role in the biodiversity of the isolated zoosporic fungi. Other authors have found that pH did not governor the distribution and occurrence of zoosporic fungi in different water habitats. Gopta and Mehrotra (1989) observed that pH value was insignificant factor affecting the occurrence of zoosporic fungi. Despite that, Lund (1934) found that a number of aquatic fungi were specific for highly acidic waters, some being fairly common and some quite rare. In addition, Khulbe (1980a), who studied the influence of pH on the distribution of zoosporic fungi in some lakes of Nainital region, India concluded that the incidence of zoosporic fungi was related to pH. He found high fungal population in lakes with pH of 7.3 to 8.8. Smith et al. (1984) mentioned that pH has complex effects not only on the activity of zoospores, mycelial growth, enzyme activity and reproduction, but also affects the availability of salts such as calcium, potassium, iron and phosphorus and the form in which nitrogen is present. Also, Shearer and Webster (1985) reported that the more acidic (pH 5.4-6) upstream portion of the River Teign had an impoverished mycobiota when compared with less acidic (pH 7-7.2) downstream portion. Other authors (Dubey 1990) reported more taxa of zoosporic fungi in alkaline waters although freshwater forms can occur across a wide pH range. Moreover, Dubey et al. (1994) isolated more taxa of zoosporic fungi from six steams, located on or near the Fernow Experimental Forest in Tucker County in West Virginia, with high pH than those from low pH.

The estimated total soluble salts of the polluted water samples fluctuated between 474 and 3200 mg/ L (Tab. 1). It had an inverse correlation with the number of the recoverable zoosporic fungal species from the collected water samples ($P \leq 0.001$). Similar results were also obtained by Harrison and Jones (1974) who found that higher salinities limited the distribution of these fungi. In contrast, Rattan et al. (1980) indicated that salinity played a non-significant role in the occurrence of *Saprolegniaceae* recovered from water samples in Shatt Al-Arab, Iraq. Gleason et al. (2006) reported that several species of Chytridiomycota could survive various salt content. Some other investigators (Te Strake 1959; El-Hissy, Khallil 1989) found that some species of zoosporic fungi could withstand a certain degree of salinity, inasmuch as they live in brackish water of estuaries.

Organic matter content of the polluted water samples varied from 150.47 to 497.10 mg/ L (Tab. 1). The result showed that the organic matter content of water drainages was positively correlated with the number of the recoverable species of zoosporic fungi ($P \leq 0.001$). Accordingly, Cantino and Turian (1959) found that some species of Saprolegniales usually depend on the presence of organic compounds for nutrition. In addition, Misra (1982) reported that the presence of organic debris is one of the probable reasons for the frequent and higher collections of zoosporic fungi from ponds having more vegetation and hence more organic matter content. Similar results were also obtained by Roberts (1963) and Okane (1978). Khulbe (1981) and El-Hissy et al. (1992) reported a significant correlation between the incidence

Table 1

Fluctuations of pH values, total soluble salts (TSS; mg/ L), organic matter content (OMC; mg/ L) and the heavy metals Cd, Pb, Co, Cu and Zn (ppm) of the collected polluted water samples (PWS) from the different drainages at seven districts in the Nile Delta area in Lower Egypt

District	PWS	pH	TSS	OMC	Cd	Pb	Co	Cu	Zn
El-Kalyobia	1-12	8.48-10.58	537-1664	150.47-189.43	0.0131-0.0149	0.0803-1.2778	0.0233-0.0252	0.0341-0.0369	0.0434-0.0475
El-Monofeyia	13-24	9.35-11.15	474-768	163.91-228.40	0.0082-0.0089	0.1426-0.3033	0.0010-0.0141	0.0296-0.0305	0.0417-0.0534
El-Gharbia	25-36	10.38-10.60	896-1984	176-280.79	0.0155-0.0177	3.1212-3.3845	0.0146-0.0417	0.0375-0.0441	0.0541-0.1755
Kafr El-Shekh	37-48	10.15-11.12	1024-2423	189.43-202.87	0.0164-0.0167	2.7248-3.2998	0.0161-0.0352	0.0410-0.0454	0.0586-0.1792
Damietta	49-60	9.58-10.38	2176-3200	163.91-189.43	0.0144-0.0159	1.4956-2.1456	0.0126-0.0164	0.0301-0.0421	0.0377-0.0381
El-Dakahlia	61-72	10.47-11.15	640-1088	214.96-241.83	0.0152-0.0154	2.2518-3.1750	0.0223-0.0464	0.0359-0.0540	0.0482-0.0528
El-Sharkya	73-84	8.36-10.71	524-832	228.40-497.10	0.0082-0.0142	1.0647-1.0755	0.0014-0.0092	0.0292-0.0379	0.0420-0.0545

of zoosporic fungi and organic matter content. However, Raviraja et al. (1998) reported a decline in aquatic hyphomycete diversity with increased organic pollution.

Analysis of the polluted water samples for the content of heavy metals (Tab. 1) showed that the value of the heavy metal Cd fluctuated between 0.0082 and 0.0177 ppm, for Pb it was ranged between 0.0803 and 3.3845 ppm, for Co 0.0010 to 0.0464, for Cu 0.0292 to 0.0540 and for Zn 0.0377 and 0.1792 ppm. These values for the heavy metals are higher with multiples than that of water samples obtained at the same unpolluted sites taken from the River Nile as reported by Soltan and Awadallah (1995). There was a parallel increment between the values of these estimated heavy metals within one sample. As the concentrations of the heavy metals in water drainages increased the number of zoosporic fungal species decreased and vice versa ($P \leq 0.001$). These results were also similar for several findings in different taxonomic fungal groups. In this connection, Maltby and Booth (1991) and Bermingham et al. (1996) reported that coal amine effluent which rich in heavy metals reduced the number of aquatic hyphomycete species by 15 to 39% compared with relatively clean, undisturbed streams. Also, Ganovas et al. (2003) isolated a filamentous fungus (*Aspergillus* sp. P37) from the Tinto River in Spain, with its high acidity and heavy metal concentration, able to grow at 15000 ppm of arsenic. They claimed that the fungus was capable of removing arsenic from culture media. In addition, Krauss et al. (2003) isolated several aquatic hyphomycetous species from polluted groundwater wells located in a former copper shale-mining district (11 sites; Mansfelder Land, Central Germany) and in the Mulde and Elbe rivers (2 sites). These locations have relatively high levels of Pb, Mn, and Fe. They found that *Heliscus lugdunensis* and *Anguillospora* sp. were the most widespread species.

The results presented in table 2 indicate that thirty four identified in addition to five unidentified species which belong to ten genera of zoosporic fungi were recovered and isolated from eighty four polluted water samples, which were collected at random from different sites at the polluted drainages along Niles´ Delta in Lower Egypt. *Pythium* and *Saprolegnia* were represented by 8 and 7 species, respectively

Table 2

Number of cases of isolation (NCI), total counts and occurrence remarks (OR) of zoosporic fungi recovered from 84 polluted drainages water samples in the Niles´ Delta region, Lower Egypt using water sesame seeds baiting technique

Zoosporic fungal genera and species	N. C. I.	Total counts	% of total counts	O. R.
Achlya total	54	445	18.63	H
A. conspicua Coker	6	49	2.05	R
A. dubia Coker	12	82	3.43	L
A. glomerata Coker	4	32	1.34	R
A. orion Coker & Couch	3	24	1.01	R
A. proliferoides Coker	23	186	7.79	M
Achlya sp.	6	72	3.02	R
Allomyces total	24	261	10.93	M
A. anomalus Emerson	8	76	3.18	R
A. macrogynus Emerson & Wilson	16	185	7.75	L
Aqualinderella fermentans Emerson & Weston	26	115	4.82	M
Aphanomyces total	25	206	8.63	M
A. helicoids von Minden	5	18	0.75	R
A. laevis de Bary	12	152	6.37	L
A. stellatus de Bary	6	31	1.30	R
Aphanomyces sp.	2	5	0.21	R
Brevilegnia total	8	59	2.47	R
B. unisperma Coker & Braxton	6	38	1.59	R
Brevilegnia sp.	2	21	0.88	R
Dictyuchus total	58	383	16.04	H
D. carpophorus Zopf.	47	268	11.22	H
D. magnusii Lindst.	2	26	1.09	R
D. sterilis Coker	9	89	3.73	R
Phytophthora total	37	155	6.49	M
P. cactorum (Lebert & Cohn) Schroeter	3	12	0.50	R
P. cinchonae Sawada	13	58	2.43	L
P. cinnamomi Rands	11	52	2.18	L
P. cryptogea Pethybridge & Lafferty	8	28	1.17	L
P. inflata Caroselli & Tucker	2	5	0.21	R
Pythiopsis cymosa de Bary	15	62	2.60	L
Pythium total	41	276	11.56	M
P. debaryanum Hesse	3	14	0.59	R
P. irregulare Buisman	4	26	1.09	R
P. proliferum de Bary	2	6	0.25	R
P. rostratum Butler	21	194	8.12	M
P. spinosum Sawada	2	5	0.21	R
P. ultimum Trow	3	14	0.59	R
P. vexans de Bary	4	11	0.46	R
Pythium sp.	2	6	0.25	R
Saprolegnia total	68	426	17.84	H
S. delica Coker	49	254	10.64	H
S. diclina Humphrey	3	16	0.67	R
S. ferax (Gruith.) Thuret	11	87	3.64	L
S. furcata Maurizio	5	23	0.96	R
S. hypogyna (Pringsheim) de Bary	2	12	0.50	R
S. uliginosa Johannes	4	19	0.80	R
Saprolegnia sp.	1	5	0.21	R
Total number of isolates	2388			

and thus they comprised the broadest spectra of the species amongst the different genera of zoosporic fungi (Fig. 2). *Saprolegnia delica* (Fig. 4) and *Dictyuchus carpophorus* (Fig. 5) were the most prevalent zoosporic fungal species (Tab. 2) during this study where they were of high frequency of occurrence (Fig. 3). These species predominated in the hyper-polluted waters with the heavy metals at the different investigated drainages in the Delta of Nile. This result was not expected and these

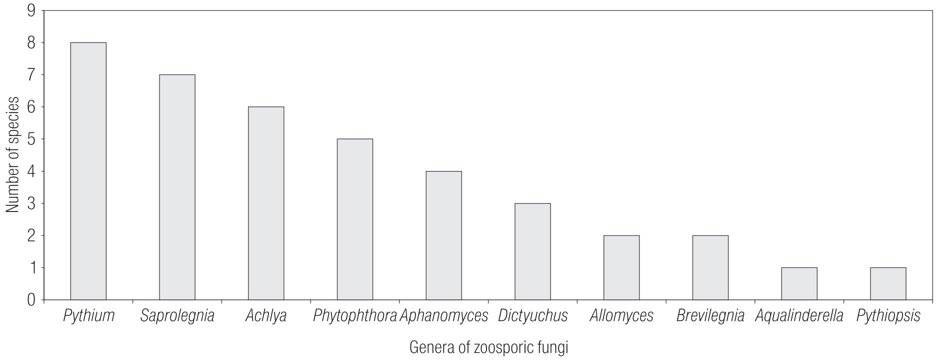

Fig. 2. Species diversity of the genera of zoosporic fungi recovered from polluted waters which were collected from different drainges in Niles Delta, Lower Egypt.

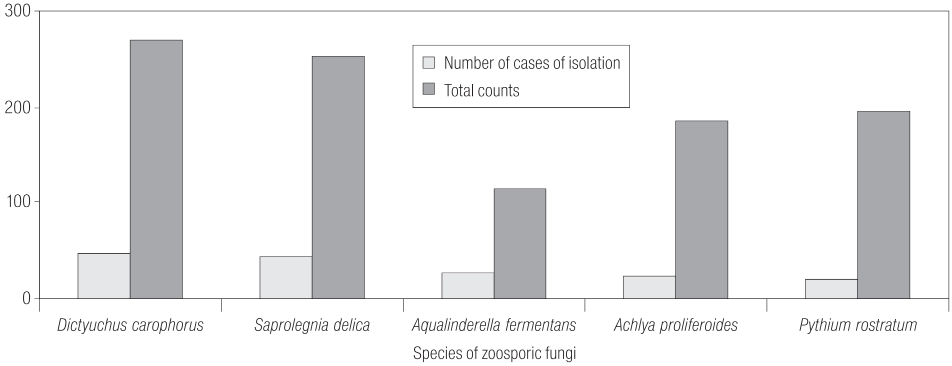

Fig. 3. Number of cases of isolations and total counts of the most prevalent species of zoosporic fungi in polluted waters which collected from different drainges in Niles Delta, Lower Egypt.

two species were considered as indicators for the water pollution in the different drainages. Several species of zoosporic fungi were recovered during this study in rare incidence.

General outlook on the overall recoverable species of zoosporic fungi during this study indicate that they poor in their numbers and specific in their composition compared with previously investigated non-extreme environments in Egypt (El-Hissy, Khallil 1989; El-Hissy et al. 1982, 1992, 2004). Accordingly, Krauss et al. (1998 and 2001) and Sridhar et al. (2000) observed that the communities of aquatic hyphomycetes in several streams are clearly impoverished but still surprisingly diverse. Nevertheless, Niyogi et al. (2002) found a decline in aquatic hyphomycete diversity in streams affected by heavy metal pollution.

The predominance of certain fungal species in heavy metals polluted sites despite the decrease in fungal number was also recorded in aquatic hyphomycetes. In this regard, several authors (Pascoal, Cassio 2004; Pascoal et al. 2005; Pascoal et al. 2003) have been consistently found the aquatic hyphomycete species *Flagellospora curta* on decomposing leaves in polluted streams in northwest Portugal.

In an interpretation for the prevalence of some species of aquatic hyphomycetes and other fungal groups in heavy metals polluted habitats; Gadd (1993), Miersch et al. (1997, 2001) and Gadd and Sayer (2000) suggested that these species have evolved some tolerance of heavy metals by synthesizing S-rich compounds and peptides derived from glutathione (phytochelatines). Several species of the isolated zoosporic fungi were illustrated in figures 4-16.

Some representative structures of the isolated species of zoosporic fungi. *Saprolegnia* was the leading zoosporic fungal genus during this study and it was of high occurrence where it was recovered from 68 polluted water samples encountering 17.84% of total count of isolates. It was represented by six identified and unidentified isolates of which *S. delica* highly occurred (49 water samples) counting 10.64% of total number of isolates. *Saprolegnia ferax* was of low occurrence (Tab. 2) whilst *S. furcata*, *S. uliginosa*, *S. diclina*, *S. hypogyna* and the unidentified species were rarely occurred as data shown in table 1. *Saprolegnia delica* was isolated for the first time during this study and it was surprising to isolate it in high frequency of occurrence. Hyper-polluted water samples of the investigated drainages were the richest in the species occurrence. In this regard, intensive researches on the occurrence of zoosporic fungi from natural water habitats in the River Nile (El-Hissy et al. 1982, 1992), in brackish water habitats in several Egyptian lakes (El-Hissy et al. 2004) and in polluted waters with industrial effluents of fertilizers (El-Hissy et al. 2001) revealed that *Saprolegnia* was also the major prevalent genus of zoosporic fungi. In addition, *Saprolegnia ferax* was encountered in a number of places in Poland including springs (Czeczuga et al. 1989), melting snow pools (Czeczuga 1992), Sunk well water (Czeczuga et al. 1987) and forest stream (Czeczuga et al. 1986). Moreover, Mehdi et al. (2001) investigated zoosporic fungi in polluted water which collected from Pasni and Ormara coasts of Pakistan using baiting and plating techniques. They isolated *Saprolegnia diclina*, *S. parasitica* and unidentified taxa of zoosporic fungi from these sites.

Dictyuchus came in the second position after *Saprolegnia* during this study and it was also of high occurrence (Tab. 2). It was included three identified species of which *D. carpophorus* was the most prevalent and highly occurred (Tab. 2). The recoverable isolates and incidence of *D. carpophorus* increased at the hyper-polluted waters with the heavy metals. The remaining species were isolated in rare frequency of occurrence and they were *D. sterilis* and *D. magnusii* (Tab. 2). *Dictyuchus* was nearly recovered either in moderate or low frequency of occurrence in different Egyptian water habitats including the River Nile (El-Hissy, Khallil 1989; El-Hissy et al. 1992, 2001, 2004; El-Nagdy, Abdel-Hafez 1990).

Achlya was isolated in high frequency of occurrence (Tab. 2) and it was matching 18.63% (445 isolates) of total number of isolates. It contributed five identified in addition to unidentified species of which *A. proliferoides* was isolated from 23 polluted water samples (moderately occurred) representing 7.79% of total number of isolates. The remaining genera were *A. dubia*, which was of low incidence (Tab. 2), *A. conspicua*, unidentified species, *A. glomerata* and *A. orion* were rarely isolated (Tab. 2). *Achlya* was previously recovered from different water habitats in Nile system and lakes in USA (Ziegler 1958), in Nigeria (Alabi 1973), in India (Hasija, Batra 1978; Khulbe 1980b; Misra 1982), in Iraq (Rattan et al. 1980) and in

Egypt (El-Hissy et al. 1982, 2004). It was contributed the broadest spectrum of species diversity in different aquatic habitats as reported by Lui and Volz (1976), Klich and Tiffany (1985) and El-Nagdy and Nasser (2000).

Pythium was of moderate frequency of occurrence (Tab. 2) counting 11.56% of total fungal isolates. It contributed the broadest spectrum of the isolated fungal species during this study where it was represented by seven identified in addition to unidentified species. Of the isolated *Pythium* species, *P. rostratum* was the most frequent where it was moderately occurred (Tab. 2). The data presented in table 2 indicate that the rest of *Pythium* species were of rare frequency of occurrence and they were *P. irregulare*, *P. vexans*, *P. debaryanum*, *P. ultimum*, *P. proliferum*, *P. spinosum* and *Pythium* species. *Pythium* came in the second position in the waters of the major lakes in Egypt as indicated by El-Hissy et al. (2004). It was also dominant in some ponds of Kharga oases (El-Nagdy, Abdel-Hafez 1990) and in waters polluted with industrial effluents of Kima factory for fertilizers at Aswan region, Upper Egypt (El-Hissy et al. 2001). *Pythium* was also recovered from water of the River Biała in Poland as reported by Czeczuga and Mazalska (1996). However, it was recovered in rare incidence from rainfall water accumulated at the common valleys in the south-eastern region in Saudi Arabia (Ali, Nasser 2001).

Phytophthora was also recovered in moderate occurrence (Tab. 2). The genus was represented by five species. Three of these namely: *P. cinchonae*, *P. cinnamomi*, *P. cryptogea* were of low occurrence (Tab. 2). The other two species *P. cactorum* and *P. inflata* were isolated in rare occurrence (Tab. 2). *Phytophthora* was also recovered in moderate incidence from surface water samples of major Egyptian lakes (El-Hissy et al. 2004) where it was contributed the broadest spectrum of species diversity. It was commonest in the lakes of hypertonic saline waters.

Aqualinderella was recovered in moderate frequency of occurrence and it was represented by only one species (*A. fermentans*, 26 polluted water samples, Tab. 2). In this regard, *Aqualinderella fermentans* was also repeatedly recovered in different incidences from different water habitats in Egypt (El-Hissy, Khallil 1989; El-Hissy et al. 2001, 2004) and Saudi Arabia (El-Nagdy, Nasser 2000). However, it was more common in stagnant than running waters in Germany (El-Hissy, Oberwinkler 1999).

Aphanomyces was also of moderate incidence (25 polluted water samples, Tab. 2) and it was included three identified in addition to unidentified species. These species were: *A. laevis* which was of low occurrence (12 water samples enumerate in 6.37% of total fungal isolates), *A. stellatus*, *A. helicoides* and *Aphanomyces* species which rarely occurred (Tab. 2). The incidence of these species of *Aphanomyces* was reported but in different frequencies from regional surface water of the River Nile at Rossetta and Damietta branches, Lower Egypt (El-Hissy, Khallil, 1989), at Upper Egypt districts (El-Hissy et al. 1982, 1992), from water samples polluted with industrial wastes of Kima factory for fertilizers at Aswan region, south Egypt (El-Hissy et al. 2001) and from the surface water of the major Egyptian lakes (El-Hissy et al. 2004). In addition, El-Nagdy, Nasser (2000) recovered *Aphanomyces laevis* in rare frequency from rainwater samples in the Riyadh, Saudi Arabia.

Allomyces was moderately isolated from 24 polluted water samples matching 10.93% of total fungal isolates. This genus was represented by two species of which *A. macrogynus* was of low incidence (Tab. 2) and *A. anomalus*, which rarely occurred

(Tab. 2). Similarly, Czeczuga and Godlewska (1994) isolated *Allomyces arbuscula* from shallow lake in forests with acid water and low mineral salt content. However, El-Hissy et al. (2004) isolated *Allomyces* species (*A. anomalus*, *A. macrogynus* and *A. moniliformis*) in rare occurrence from the surface waters in major four Egyptian lakes.

Pythiopsis: P. cymosa was of low frequency of occurrence where it was isolated from 15 polluted water samples constituting 2.60% of total fungal isolates.

Brevilegnia was isolated in rare frequency of occurrence where it was emerged from 8 polluted water samples comprising 2.47% of total fungal isolates. It included two species, *B. unisperma* and *Brevilegnia* sp. which were of, low occurrence (Tab. 2). In this regard, Steciow (2003) isolated *Brevilegnia ensenadensis* from a man made polluted channel near a petroleum refinery in Buenos Aires Province in Argentina.

General outlook on the recoverable species of zoosporic fungi during this study indicated that the prevalence of *Saprolegnia delica* and *Dictyuchus carpophorus*. *S. delica* was isolated for the first time from Egyptian water habitats and it was surprised to isolate it in high occurrence. *D. carpophorus* was almost previously recovered in rare incidence from other different Egyptian water habitats. It can be concluded that the effect of the pollution in the water environment can lead to changes in the structure and function of zoosporic fungi as it was represented and reflected in the biodiversity of the isolated species. Also, the frequent presence of these two species of zoosporic fungi at metal polluted sites suggests that they should have mechanisms to overcome metal toxicity. So, further investigations should be necessary on the effect of the heavy metals on various aspects of zoosporic fungi.

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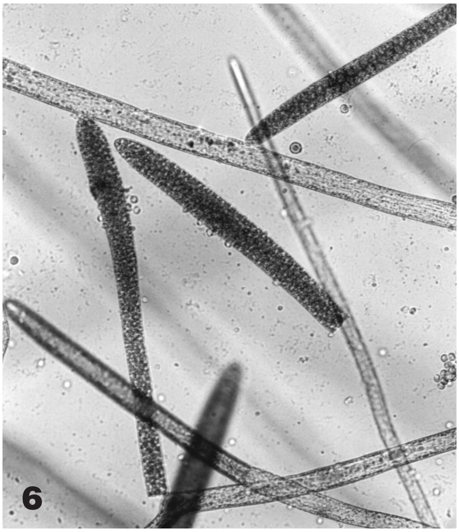
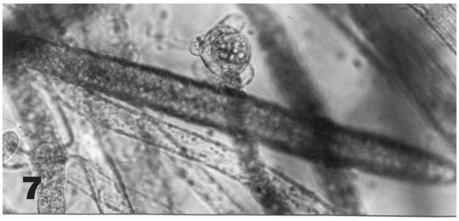
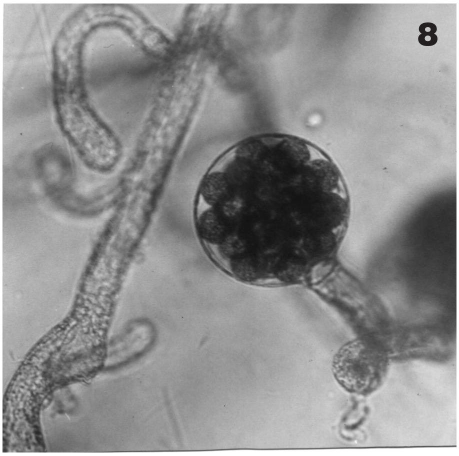
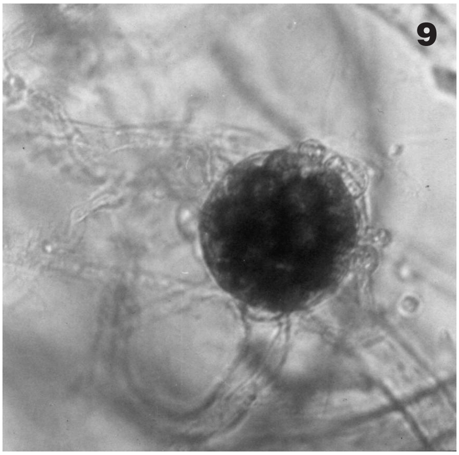
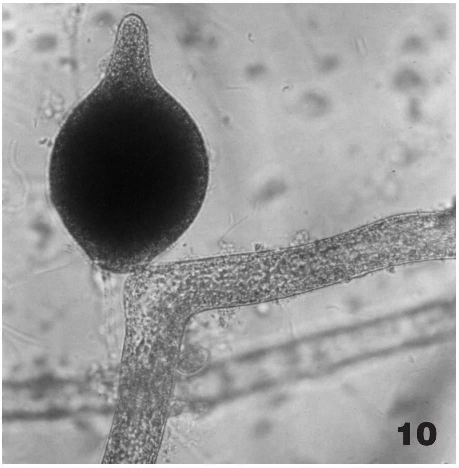








Figs 4-9. Fig. 4. *Saprolegnia delica* – oogonia with diclinous and androgynous antheridia; Fig. 5. *Dictyuchus carpophorus* – dictyoid-zoosporangia and eccentric oogonium with characteristic single oosphere; Fig. 6. *Dictyuchus sterilis* – showing only sympodial, dictyoid-shaped zoosporangia and lacking sex organs; Fig. 7. *Dictyuchus magnusii* – dictyoid-zoosporangium and sex organs; Fig. 8. *Saprolegnia furcata* – oogonium with coiled oogonial stalk; Fig. 9. *Saprolegnia diclina* – diclinous antheridium completely encircling an oogonium.



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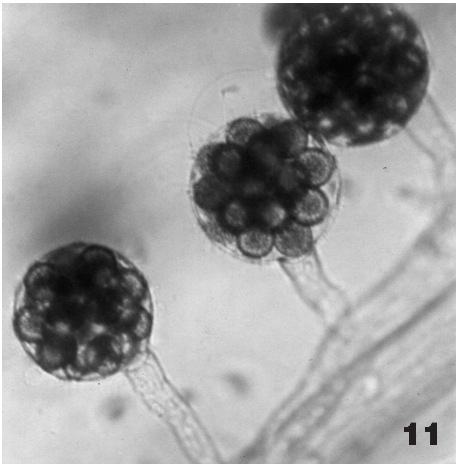

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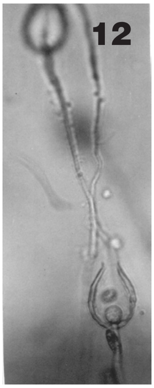

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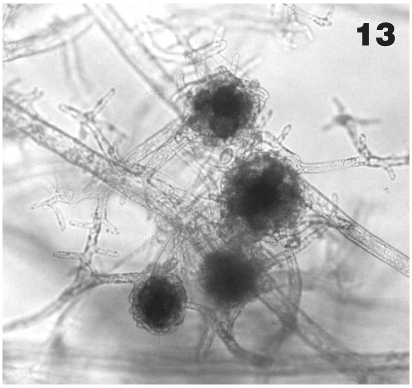

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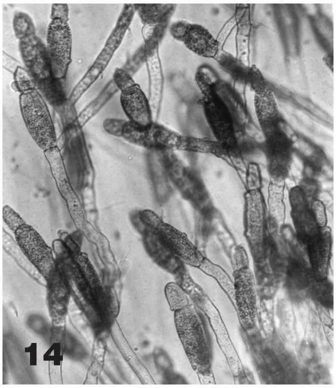

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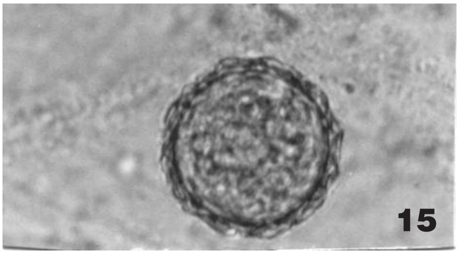

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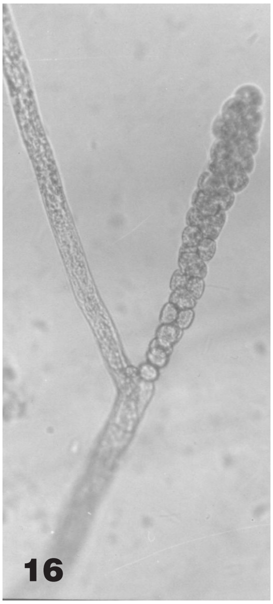

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Figs 10-16. Fig. 10. *Pythiopsis cymosa* – coenocytic hypha bearing single globular sporangium; Fig. 11. *Saprolegnia ferax* – spherical oogonia having no antheridial attaches; Fig. 12. *Phytophthora cinchonae* – proliferated, lemon-shaped zoosporangia; Fig. 13. *Achlya proliferoides* – antheridial branches closely twined around the vegetative hyphae and oogonia; Fig. 14. *Allomyces macrogynus* – gametophyte bearing gametangia in pairs with the epigynous male gametangia and the hypogynous female gametangia; Fig. 15. *Pythium irregulare* – plerotic oospore with distinguished irregulare surface; Fig. 16. *Brevilegnia* sp. – zoosporangium showing typical brevielegnoid discharge.