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**TAXONOMY AND ECOLOGY OF FUNGI IMPERFECTI FROM FOUR
LOCATIONS IN UTAH LAKE, UTAH CO., UTAH**

A Thesis

Presented to the

Department of Botany and Range Science

Brigham Young University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Laird M. Hartman

May, 1970

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INTRODUCTION AND REVIEW OF LITERATURE

Description of Utah Lake

Since Pleistocene times, the water of Lake Bonneville has been receding, and a pluvial lake has been formed at the base of the Wasatch Mountains in Utah County, Utah. This body of water is Utah Lake and is the only fresh-water remnant of the old Lake Bonneville. Its size fluctuation is due to several factors, some of which are; the varied amounts of run-off water from year to year, increased demands for irrigation water, and evaporation. It is located in North Central Utah at the latitude of $40^{\circ} 2' 30'' - 40^{\circ} 2''$ N long: $111^{\circ} 30' - 111^{\circ} 40'$ wide and at an altitude of 1,370m, (4,487 ft) with a maximum depth of 5.5m (20 ft) and the mean depth of 3m (9 ft). The volume of the lake varies considerably and this fluctuation of the water level is a primary factor in the polluted state of the lake today. The limnological classification of Utah Lake is eutrophic and turbid when no ice cover is present. The present uses of the lake include: (a) Recreation (boating, swimming, water skiing, sailing and fishing). (b) Sport fishery and water-fowl hunting. (c) Commercial fishery (carp Cyprinus carpio). (d) Reservoir for the Jordan River irrigation system. (e) A biological oxidation system for treated sewage. (f) Settling pond for industrial washings.

Early colonization of Utah County took place around the

1850's, and since that time Utah Lake has been the recipient of human and animal wastes. Wastes have also been emptied into the lake from industry, agricultural enterprises, sewage treatment plants and fresh water tributaries. This has resulted in the accumulation of organic nutrients in large quantities throughout the lake. According to Bradshaw et al., (1969), chemical analysis of the water revealed that large amounts of phosphates were present in the water throughout the lake. Most of the present day laundry detergents contain polyphosphates as builders, therefore, the increased amounts of phosphate in the lake, must be due to a great influx of detergents in the effluent, from the sewage treatment plants (Bradshaw, et al., 1969).

Utah Lake, being a eutrophic lake, has a water temperature favorable for growth of microorganisms. Abundant amounts of organic nutrients are made available for growth of these microorganisms by the continual mixing of the bottom sediments of the lake. Organic nutrients and large amounts of phosphates in the water, favor rapid growth of algae and phytoplankton which are referred to as algal and phytoplanktic blooms (Fig. 1). These blooms occur most intensively during the summer months when the water temperature is warm and mixing of the bottom sediments occurs most frequently. The algae and phytoplankton undergo photosynthesis during the daylight hours and release oxygen and water as by-products of this process.

Purpose of Study

Fungi utilize dissolved oxygen in the water and are capable of competing satisfactorily with other aquatic organisms for the dissolved oxygen present. Cooke (1963) stated that it is possible for fungi imperfecti to utilize the oxygen released through photosynthesis and live submerged in the water in association with the algae and may become part of the phytoplankton suspended in the water (Fig. 2). The phytoplankton and algal blooms die and provide an abundant source of organic matter for the saprophytic fungi. These fungi obtain carbon, necessary for growth and metabolism, from the decomposition of this organic material. Another source of nutrients for the fungi is the presence of organic pollutants and sludges which result from excess pollutants in the water (Cooke 1967). Organic pollutants are materials which are decomposed by the fungi and other aquatic organisms, and upon decomposition of this organic matter, the fungi and other aquatic organisms deplete the dissolved oxygen content of the water. Most fungi imperfecti exist as saprophytes in the lake and maintain their populations through asexual reproduction. According to Crane (1968) there is a possibility that an alternation between an aquatic conidial stage and a terrestrial perfect stage may exist. This perfect stage may vary in its mode of nutrition, ranging from a saprophyte to a facultative parasite, or a facultative saprophyte, to a highly pathogenic obligate parasite.

The biota of Utah Lake has changed noticeably over the last hundred years (White et al., 1969). No previous work has been done on the fungi imperfecti of Utah Lake, therefore, no



Fig. 1. Algae and Phytoplankton Blooms in the Water of Utah Lake.



Fig. 2. Filamentous Fungi Growing in Association with Algae in the Water of Utah Lake.

comparison can be drawn concerning the changes which have occurred in this portion of the lake's biota.

The primary interests of this study were to isolate and identify fungi imperfecti present in the water and in the bottom sediments at four locations in Utah Lake. Reasons for choosing the four different sites for sample stations is described under the section, Study Sites. Because Utah Lake is a polymetic lake, I was interested in knowing if the same fungi imperfecti present in the lake were also present in the Jordan River outlet. It was of primary interest to determine if any of the fungi imperfecti present in Utah Lake were potential plant, animal, or human pathogens. Physical data were also collected to help understand the ecology of Utah Lake and determine what function the fungi imperfecti perform in the Utah Lake ecosystem.



STUDY SITES AND DATES OF SAMPLING

Four locations were chosen to determine what variations if any, exist in the fungal flora at each sample site. The four study sites are as follows: (a) The mouth of the Provo River which is the largest fresh-water tributary of Utah Lake, (b) a large shallow area at Mud Lake, known for its high nitrogen content, (c) the entrance of the Spanish Fork River into the lake which is a large fresh-water tributary and contains a wide variety of waste products from industry and agricultural enterprises, (d) an area at the source of the Jordan River, which is the only natural outlet of Utah Lake. One sample was also collected from Pelican Point which is located on the West side of Utah Lake (Fig. 3).

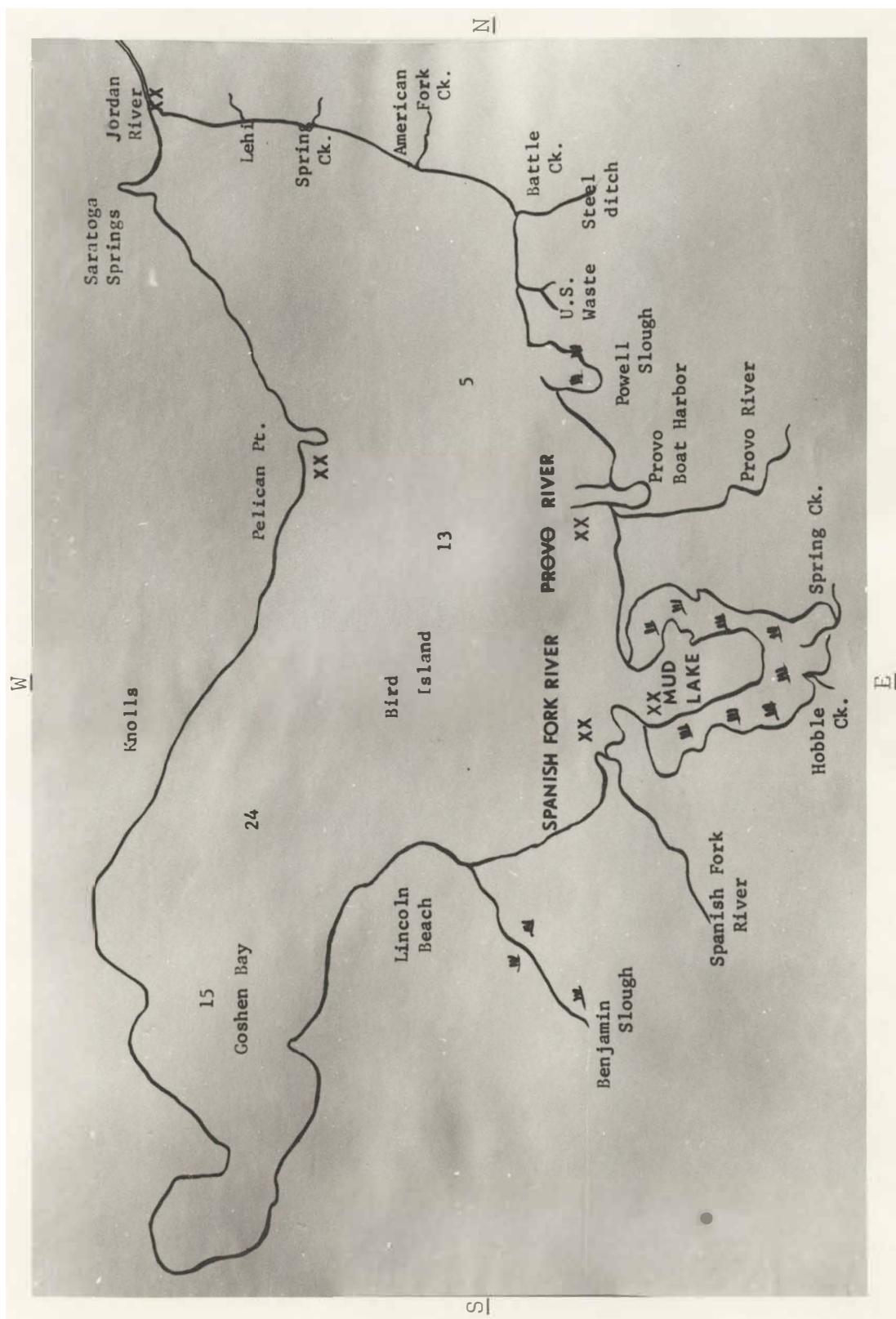


Fig. 3. Map of Utah Lake Showing Sample Study Areas.

Personel from the Brigham Young Universities, Utah Lake biological station, collected samples twice weekly from June 1, to September 27, 1969. Samples for this study were collected on June 19, with subsequent samples collected at one month intervals. These samples were collected in association with the Utah Lake study group so that data might be compared. Sampling dates were: June 19, July 15, August 26, and September 27, 1969.

The majority of the human population and agriculture practices of Utah County are located along the Eastern boundries of Utah Lake. Also situated along the Eastern shores of the lake are the major industries of Utah County and all of the sewage disposal units located in the Utah Valley area. Because of the large human population, industry, and agricultural practices in the area, much larger quantities of organic matter are emptied into Utah Lake from the Eastern boundries than from the West side of the lake. Lower concentrations of organic matter exist on the West side of the lake when compared to the East side. The number of fungi per sample of water and bottom sediment were completed, comparing the number of fungal colonies from the East and West sides of the lake (Fig. 4). Only one sample was collected at Pelican Point and the fungal colonies from this station were only counted and not identified.

MATERIALS AND METHODS

Collection of Water Samples

Surface samples were collected in sterile screw-topped glass bottles from the side of the boat. The samples were then

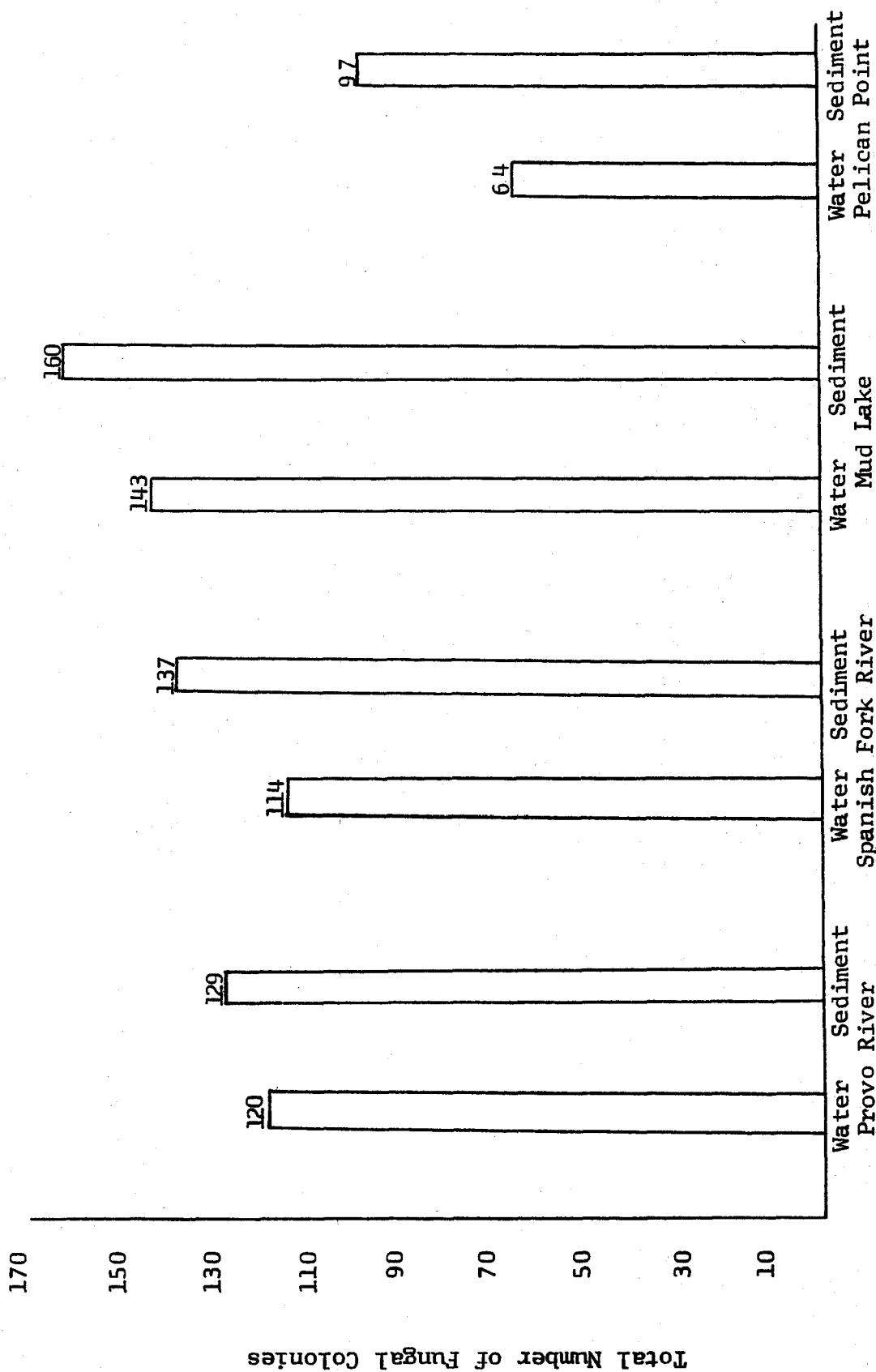


Fig. 4. A comparison of the number of fungal colonies collected September 27, 1969, from Pelican Point in contrast to those stations on the East side of the lake.

placed in an ice bath and returned to the laboratory for culturing. The surface water samples were collected from Mud Lake August 26, 1969. These samples were in addition to the regularly collected water samples, and were used to determine if fungi exist in the water as mycelial filaments, (Fig. 2).

Collection of Bottom Sediments

The bottom sediments were collected with the Echman Dredge. This instrument was washed with soapy water and autoclaved for 15 minutes at 15 pounds pressure and 121°C before each sampling date. Between sample stations it was rinsed with 95% ethyl alcohol, then with sterile distilled water. The bottom sediment samples were collected in sterile screw-topped glass bottles using aseptic techniques. Samples were then returned to the laboratory for culturing. All samples were plated on Neopeptone-Dextrose Agar the same day as collected to avoid creating an anaerobic condition within the sample bottles.

Bottom Sediment Analyses

The percentages of sand, silt, and clay were determined by mechanical analysis using the hydrometer method (Bouyoucos, 1936). The percent of organic matter was determined by a dry combustion method (modified from Piper, 1944). Five grams of soil were oven dried overnight at 105°C to remove the water, then weighed and ignited in a muffle furnace at 350°C for twelve hours and re-weighed. The loss of weight due to the ignition was assumed to be the principal organic matter content of the sample.

These sediment analyses were conducted with duplicate samples from each sample station.

Water Analyses

Water analyses were completed on the Spanish Fork River, Mud Lake, and Provo River Stations. These analyses consisted of determination of hydrogen-ion concentration in the field with the use of a battery-powered Sargent-Welch pH-meter. The dissolved oxygen content from the surface water was determined by the use of the Hach Kit. The surface and bottom water temperature was also measured at each station using the Bead Thermistor.

Preparation of Isolation Plates

A modified dilution method of Cooke (1963) was used. Five petri dishes were prepared for each water and bottom sediment sample. Five control plates were also prepared for each sampling date. All petri dishes and other necessary equipment were sterilized in the autoclave and aseptic techniques were employed in plating of the samples. These petri dishes will be referred to as isolation plates from this section forth. The bottom sediment samples were diluted with distilled water to one part of sediment in 1,000 parts of water. Ten ml of the 1/1,000 diluted sample were transferred to the isolation plates. This dilution method of bottom sediment samples produced between 25 and 35 fungal colonies per isolation plate. No dilution was necessary on the water samples because plating directly produced an average of 25 fungal colonies on each isolation plate.

A commercially prepared synthetic medium was used for culturing the fungi. This prepared medium is Neopeptone-Dextrose Agar with Rose Bengal and Aureomycin added. The ingredients of Neopeptone-Dextrose Agar include sufficient mineral and vitamin compounds so that the addition of macro- and microelements is not necessary (Cooke 1963). The Rose Bengal is added to slow down the growth rate of fast growing fungi that otherwise would crowd out or cover some of the slower growing species. Aureomycin was added to eliminate or inhibit the large numbers of bacteria found in polluted habitats (Cooke 1963). The formula of Neopeptone-Dextrose Agar is as follows:

Ingredients Per Liter

Beef Heart Infusions.....	454.0 gm
Neopeptone.....	10.0 gm
Dextrose.....	0.5 gm
Sodium Chloride.....	5.0 gm
Disodium Phosphate.....	2.5 gm
Agar.....	15.0 gm

Forty-four grams of medium were mixed with one liter of distilled water and 33.0 mg of Rose Bengal. The solution was then brought to a boil to dissolve the ingredients and was then autoclaved for 15 minutes at 15 pounds of pressure at 121°C. When the solution had cooled to approximately 45°C, 30.0 mg of Aureomycin were added. The solution was then poured into the isolation plates which contained the samples and swirled to mix the two solution. When the agar had solidified, the isolation plates were sealed with parafilm and stored at 25°C for seven days.

Isolation Procedure

Isolations were made by transferring mycelia from each unique fungal colony of each isolation plate to individual agar slants containing Neopeptone-Dextrose Agar. Rose Bengal and Aureomycin were not added to the agar slants. If after microscopic examination, the fungus was not identified, it was then transferred to culture tubes containing Czapek-Dox Agar for future more detailed examination.

Johnson et al., (1959) recorded the formula of this medium as follows:

Ingredients Per Liter

Agar.....	15.00 gm
NANO ₃	3.00 gm
K ₂ HPO ₄	1.00 gm
KCL.....	.50 gm
Fe SO ₄ 7H ₂ O.....	.01 gm
Sucrose.....	30.00 gm
Water (distilled).....	1,000.00 ml

Identification Procedure

Agar slants from each sample were sorted and grouped according to each discrete fungus strain determined by microscopic characteristics. Further microscopic examination was employed if necessary for proper identification.

Phloxene B was used as a staining agent and wet mount slides were prepared from each fungus colony according to date and station number. When semi-permanent slides were prepared, Amman's mounting medium was used. This medium contains the following ingredients:

Phenol	20 gm
Lactic Acid	20 gm
Glycerine	40 gm
Distilled Water	20 ml

A 0.05% to 0.1% solution of cotton blue was used to stain the protoplasm (Alexopoulos and Beneke 1968).

Manuals used for identification included: Barnett (1960), Gilman (1966), Barron (1968), Cooke (1963), Clements and Shear (1964), Thom and Raper (1945), Bessey (1964), Raper and Fennell (1965), Raper and Thom (1968), Toussoun and Nelson (1968) and Stevens (1913). The color manual used for the Penicillia and Aspergilli was the Dictionary of Color by Maerz and Paul (1950).

Many of the concepts used in preparation of the manuscript and in gaining background information were obtained from the following: Agrios (1969), Alasoadura (1968), Alexopoulos (1962), Becker and Shaw (1954), Cooke (1968), Cooke (1967), Martin (1962), Peterson (1963b), Ranzoni (1953), Reid (1961), Robinson (1967), Walker (1969).

Figure Preparation

Figure 9 was prepared by Charlotte Chamberlain from 35mm slides taken of the fungus after being cultured from Utah Lake.

RESULTS

Bottom Sediment Analyses

The percent of organic matter varied between sample stations ranging from a high of 9.4% at Mud Lake, to a low of 0.6% at Pelican Point. Variations also occurred between stations for the percentages of sand, silt, and clay. The percent sand varied from 67.9% at Provo River, to a low of 11.1% at Jordan River Outlet. Silt percentages ranged from 34% at the Spanish Fork River, to 14.1% at the Jordan River Outlet. The amounts of clay ranged from 74.8% at the Jordan River Outlet, to a low of 6.2% at the Spanish Fork River. The overall readings concerning percent organic matter, sand, silt, and clay are presented in (Table 1).

Water Analyses

The hydrogen-ion concentration (pH) of the water varied at each sample station and at each sampling date. The water pH was basic at all sample stations and sampling dates ranged from a low of 8.3 to a high of 8.8. The ppm of dissolved oxygen was in direct relation to water temperature. A greater variation occurred in the surface water temperature than in the bottom temperature, (Table 2).

Table 1. Percentages of organic matter, sand, silt and clay. The texture of the bottom sediments and the total number of fungal strains per water and bottom sediment samples.

Sample Stations	% Organic Matter	% Sand	% Silt	% Clay	Sediment Texture	Total Strains Water	Total Strains Sediments
Mud Lake (ULS-21)	9.4	66.5	18.9	14.6	Sandy Loam	50	57
Provo River (ULS-3)	1.6	67.9	18.0	14.1	Sandy Loam	35	46
Spanish Fork River (ULS-19)	2.5	59.8	34.0	6.2	Sandy Loam	43	47
Jordan River Outlet (ULS-10)	0.8	11.1	14.1	74.8	Clay	26	35
Pelican Point (ULS-12)	0.6	56.8	29.4	13.8	Sandy Loam	Not Identified	

Table 2. The dissolved oxygen content of the water, hydrogen-ion concentration, and temperature of the bottom and surface levels during the summer of 1969.

Date (1969)	Station	Surface Water Temperature °C	Bottom Water Temperature °C	Dissolved Oxygen ppm	Hydrogen-Ion Concentration
June 19	Spanish Fork River	17.7	16.9	8.0	8.6
	Mud Lake	18.6	18.3	12.0	8.8
	Provo River	17.0	14.9	9.0	8.6
July 15	Spanish Fork River	23.3	22.8	6.6	8.6
	Mud Lake	22.5	22.2	—	8.7
	Provo River	25.9	23.3	—	8.7
August 26	Spanish Fork River	22.8	23.2	4.2	8.5
	Mud Lake	22.1	22.2	7.4	8.3
	Provo River	26.9	23.7	—	8.7
September 27	Spanish Fork River	21.0	21.0	5.6	8.4
	Mud Lake	19.7	19.7	6.6	8.8
	Provo River	19.5	17.8	8.7	8.8

Fungal Isolation and Identification

A total of 138 different strains of fungi were identified from the water and bottom sediments at four locations in Utah Lake. There were 43 different species isolated from the water of the Spanish Fork River Station, and 47 different species from the bottom sediments which were collected at that site. Fifty species were collected from the water and 57 species from the bottom sediments at Mud Lake. Thirty-five species were isolated from the water and 46 species from the bottom sediments at the Provo River Station. At the Jordan River Outlet, 26 species were collected from the water and 35 were collected from the bottom sediments (Table 3).

Presence of Potential Human and Animal Pathogens

Potential human and animal pathogenic fungi cultured from Utah Lake included six species of Aspergillus, (Table 4). Of these six species, Aspergillus fumigatus occurs most abundantly in nature. It appeared in the water sample of the Spanish Fork River Station and in the bottom sediments at the Jordan River Outlet on September 27, 1969. Certain strains of this fungus cause serious systemic human diseases and this fungus ranks as a major pathogen of animals, particularly of birds. These fungi are highly pathogenic organisms, they are found frequently in the soil and were commonly reported from sewage effluent and polluted water in Ohio by Cooke and Kabler (1955). Three ways in which species of this genus of fungi can be contributed to Utah Lake are: Carried from the soil by irrigation water, from the effluent of sewage

Table 3. A list of the species, their abundance in water and bottom sediments, and the dates on which the samples were collected.

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	a b c d	a b c d	a b c d	a b c d
<i>Acremonium</i> sp. Link	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
<i>Acrophialophora</i> <i>nainiana</i> Edwards	1															1
<i>Acrostalagmus</i> <i>cinnabarinus</i> Corda.					1											
<i>Acrostaphylus</i> <i>lignicola</i> Arnaud.						1										
<i>Alternaria</i> <i>humicola</i> Oudemans							1	1								
<i>tenuis</i> Ness									1	1						
<i>Amblyosporium</i> <i>botrytes</i> Fres	1		1					1								

Key to symbols: a- June 19, 1969 Abundance Classes
 b- July 15, 1969 1- Species Present
 c- August 26, 1969 2- Species Common
 d- September 27, 1969 3- Species Abundant

Jordan River Outlet was not collected July 15, 1969

Table 3. (continued)

Table 3. (continued)

Species	Spanish Fork River				Provo River				Jordan River			
	Water		Sediment		Water		Sediment		Water		Sediment	
	a	b	c	d	a	b	c	d	a	b	c	d
<i>Versicolor</i>												
<i>Tiraboschi wentii</i> Wehmer	1	1	1		1		1		1		1	
<i>Aureobasidium*</i> pullulans (de Bary) Arna.				1				1				1
<i>Botryothrichum piluliferum</i> Sacc. & March.									1			
<i>Candida krusel</i> (Castellani) Berkhoult					1		1	1				
sp. #1									1			
sp. #2												
<i>vobusta</i> Diddens & Lodder									1			
<i>Cephalosporium</i> sp.												1
<i>Chaetoploca confluens</i> Cooke												1
<i>Chalaropsis</i> sp.												1

*This genus may be a synonym of Pythiella

Table 3. (continued)

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water		Sediment		Water		Sediment		Water		Sediment		Water		Sediment	
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
<i>Chalara quereina</i> Corda.	1				1				1				1			
<i>Chloridium chlomydosporis</i> (Van Beyma) Huges		1				1			1				1			
<i>Cladodermatum glaucum</i> Link	1				1				1				1			
<i>Cladodermatum viride</i> Link		1				1			1				1			
<i>Cladosporium cladosporioides herbanum</i> (Pers.) Link			1				1						1			
<i>Coniothyrium lignicolum</i> Corda				1									1			
<i>Coniothyrium sphaerosporum</i>													1			
<i>Cordana pauciseptata</i> Preuss.	1												1			
<i>Cylindrocephalum coprophilum</i> Bon.		1											1			
<i>Dwayamala prathilomaka</i> Subram.													1			

Table 3. (continued)

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	a b c d	a b c d	a b c d	a b c d
<i>Fumago vagans</i> Pers.					1				1						1	
<i>Fusarium aqueductium</i> (Radlmacher & Rabenhorst)			1						1							
<i>Saccardo nival</i> (Fries)									2							
<i>Cesati oxysporum</i> Schlechtendahl			1						1							
<i>roseum solani</i> (Martius) Appel & Wollenweber									1							
<i>Fusidium griseum</i> Link									1							
<i>viride</i> Grove sp. #1 Link									2							
<i>Geotrichum albidiuum</i> Link										1						
sp. #1 Link										1						
<i>Gliomastix murorum</i> (Corda.) Huges											1					

Table 3. (continued)

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	a b c d	a b c d	a b c d	a b c d
<i>murorum</i> var <i>Felina</i>									1						1	
<i>Gonatobotrys</i> <i>simplex</i> Forda.																
<i>Graphium</i> sp. Corda.	1															
<i>Helicoon</i> <i>sessile</i> Morgan		1														
<i>Helicosporium</i> <i>vegetum</i> Nees.			1													
<i>Hormisciella</i> <i>atva</i> Batista				1												
<i>Hormiscium</i> <i>stilbosporum</i> (Corda.) Sacc.					1		1									
<i>Humicola</i> <i>brevis</i> (Gilman & Abbott) Gilman								2								
<i>Itersonilia</i> <i>perplexans</i> Devx.													1			

Table 3. (continued)

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	a b c d	a b c d	a b c d	a b c d
<i>Margarinomyces bubaki</i> Laxa.	1								2				1			
<i>Memnoniella echinata</i> Hohn	1	2			1	1	1									
<i>Monilia cinerae</i> var. <i>Americana</i>				1			2	1								
<i>fructigena</i> Pers. <i>pruinosa</i> Cooke & Massee sp. #1 Pers.							1									
<i>Monosporium acuminatum</i>			1						1	1	1		1			
<i>Saccardo rubrum</i> Bon. <i>silvaticum</i> Oudemans	1		1			2		2		1		2	1	1	2	1
<i>Mycelia sterelia</i> #1 sp. #2 sp. #3 sp. #4												1				
<i>Nodulisporium hinnuleum</i> Smith												3				1

Table 3. (continued)

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water		Sediment		Water		Sediment		Water		Sediment		Water		Sediment	
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
<i>Oedocephalum</i> sp. Preuss.													1	1		
<i>Oidiodendron</i> <i>griseum</i> Robak	1															
<i>Paecilomyces</i> sp. Bainier		1														
<i>Papularia</i> <i>arundinis</i> sp. # 1 Fries			1	1					1	1						
<i>Penicillium</i> <i>atramentosum</i> Thom <i>brefeldianum</i> Dodge <i>brevi-compactum</i> Diercky									1	1						
<i>capsulatum</i> Raper & Fennell								2								
<i>chermesinum</i> Bjorge									1	1			1	1	1	
<i>chrysogenum</i> Thom <i>citrinum</i> Thom <i>coryophilum</i> Diercky	1	1							1	1			1	1	1	
<i>decumbens</i> Thom <i>frequentans</i> Westling													1			1

Table 3. (continued)

Table 3. (continued)

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water		Sediment		Water		Sediment		Water		Sediment		Water		Sediment	
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Ramalia veronicae Batista.																
Rhinocladium coprogenum Sacc. & March brumptii Bain.					1				1				1			
Rhizoctonia solani Kuhn									1	2			1			
Scopulariopsis brevicaulis (Sacc.) Bain. brumptii Bain	1	1							1	1			1			
Sepedonium chrysospermum (Bull) Link													1			
Spicaria sp. Auct.													1			
Sporobolomyces salmonicolor Kluy & Niel.													1	1		
Sporotrichum carnis Brooks & Hansford													1			

Table 3. (continued)

Table 3. (continued)

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water		Sediment		Water		Sediment		Water		Sediment		Water		Sediment	
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
<i>Verticillium</i> albo-atrum Reinke & Berthold	1		1				2	1	2		1	2		1		1
<i>Lateritium</i> Berkeley terrestre (Link) Lindau				2		1				1						
<i>Wardomyces</i> <i>anomala</i> Brooks & Hansford												1				
<i>Phycomyctes</i>	1	2	2	1	2	2	2	1	2	3	1	2	2	1	3	2

Table 4. Potential human, and animal pathogenic fungi in water and bottom sediments of Utah Lake including their abundance, stations and dates collected.

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	a	b	c	d
a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d	
<i>Aspergillus flavus</i>			1	1												
<i>Aspergillus flavus</i> var <i>columnaris</i>						1										
<i>Aspergillus fumigatus</i>	1								1							
<i>Aspergillus nidulans</i>							1									
<i>Aspergillus sydowii</i>								1								
<i>Aspergillus versicolor</i>	1								1							

Key to Symbols: a- June 19, 1969
b- July 15, 1969
c- August 26, 1969
d- September 27, 1969

Abundance Classes
1- Species Present
2- Species Common
3- Species Abundance

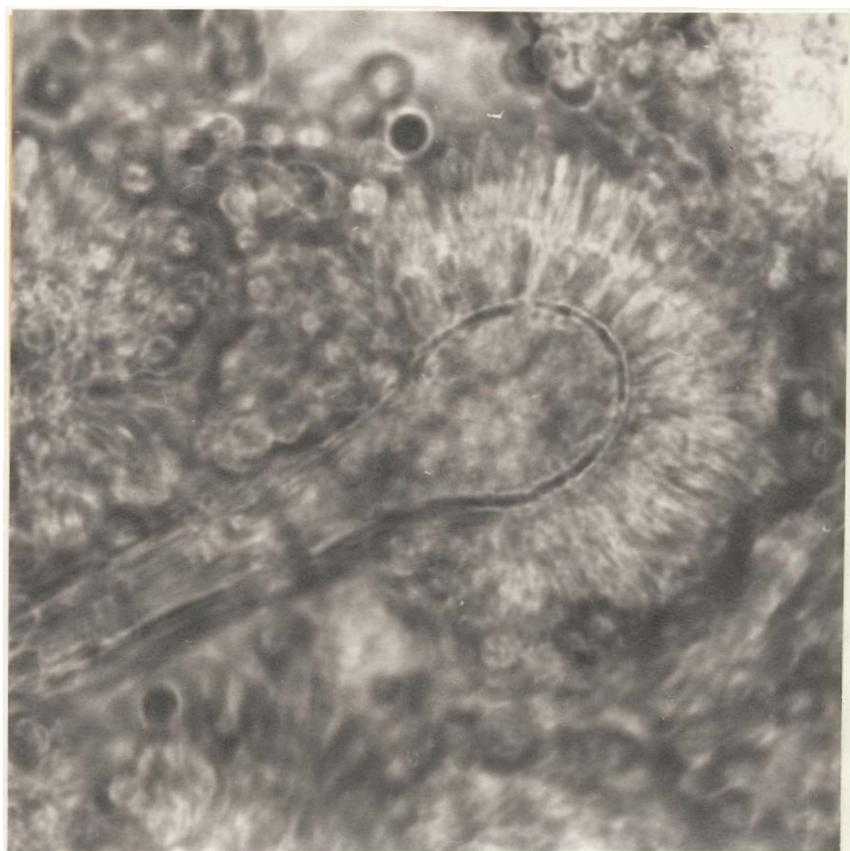


Fig. 5. Aspergillus sydowii - a potential human and animal pathogen

disposal installations, or from infected migratory waterfowl.

Aspergillus flavus is not as wide spread as is A. fumigatus, and has been cultured from only one station at Utah Lake. Strains of this fungus can be pathogenic to man and animals, and the same fungus is a common soil inhabitare. Aspergillus sydowii was cultured from two stations of Utah Lake (Fig. 5). Some doubt about the ability of this fungus to cause disease exists, but it has been cultured from human lesions, and it is also a common soil mold.

Cooke and Kabler (1955) stated, "the presence of pathogenic fungi in any habitat does not necessarily imply the wide spread occurrence of the disease caused by them, nor does it imply the presence of a case of illness attributable to the disease in the immediate vicinity".

Potential Plant Pathogens

Twenty-two species of potential plant pathogenic fungi were isolated from the water and from the bottom sediments of Utah Lake, (Table 5). Five of the most serious potential plant pathogens are: Rhizoctonia solani, which causes damping off of many vegetable crops, (Fig. 6); Fusarium oxysporum, which was isolated from all four study stations, (Fig 7); some strains of this fungus are highly pathogenic and invade the xylem vessels of their host causing vascular wilts to occur; Fusarium solani, which causes damping off of potatoes, and Vorticillium albo-atrum was collected from all study stations, (Fig. 8). This latter fungus is a potential pathogen which may cause vascular wilts in higher

Table 5. Potential plant pathogenic fungi isolated from water and bottom sediments of Utah Lake.

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River			
	Water		Sediment		Water		Sediment		Water		Sediment		Water		Sediment	
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
<i>Acrostalagmus cinnabarinus</i>									1							
<i>Alternaria tenuis</i>	1	1					1		2				1			
<i>Aspergillus niger</i>						3			1							
<i>Cephalosporium</i> sp.					1			1								
<i>Chalaropsis</i> sp.	1				1					1			1			
<i>Chalara quereina</i>						1										

Key to symbols: a- June 19, 1969 Abundance Classes
 b- July 15, 1969 1- Species Present
 c- August 26, 1969 2- Species Common
 d- September 27, 1969 3- Species Abundant

Jordan River Outlet was not collected July 15, 1969

Table 5. (continued)

Species	Spanish Fork River	Mud	Lake	Provo River	Jordan River
	Water	Sediment	Water	Sediment	Water
	a b c d	a b c d	a b c d	a b c d	a b c d
<i>Cladosporium herbarium</i>					
<i>Coniothyrium sp.</i>	1				
<i>Fusarium aquaeductum</i>					
<i>oxysporum</i>	1				
<i>roseum</i>					
<i>solani</i>					
<i>Graphium sp.</i>	1				
<i>Itersonilia perplexans</i>		1			
<i>Monilia cinerae</i> var <i>americana</i>			2	1	
<i>Penicillium brevi-compactum</i>			2	1	1
<i>chrysogenum</i>					1
<i>oxalicum</i>					1

Table 5. (continued)

Species	Spanish Fork River				Mud Lake				Provo River				Jordan River				
	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	a b c d	a b c d	a b c d	a b c d	
<i>Phialophora</i> sp.					1												
<i>Rizoctonia</i> <i>solani</i>					2				1								
<i>Sporotrichum</i> sp. #1								1									
<i>Vorticillium</i> <i>albo-atrum</i>	1	1	1	1		2	1	2	1	2	1	1					



Fig. 6. Rhizoctonia solani - a potential plant pathogen



Fig. 7. *Fusarium oxysporum* - a potential plant pathogen

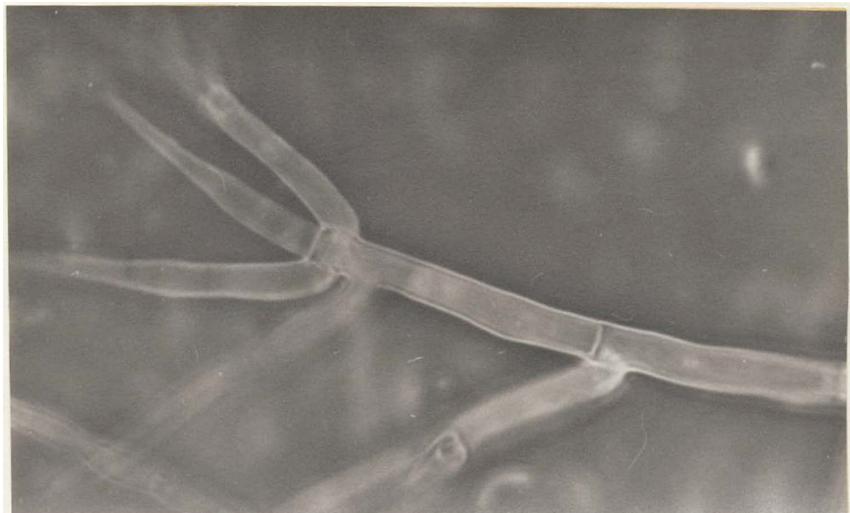


Fig. 8. *Virticillium albo-atrum* - a potential plant pathogen

plants. Alternaria tenuis is a secondary parasite and enters the host through wounds produced by primary parasites, (Fig. 9). For the complete list of potential plant pathogenic fungi, refer to (Table 5).

Saprophytic Fungi Imperfecti

The majority of fungi imperfecti in Utah Lake exist as saprophytes. Hormiscium sp. is a saprophytic fungus and its entire mycelium develops into chains of rounded or oblong one-celled conidia (Fig. 10). Cladosporium sphaerosporum produces blastospores in branching chains. The conidial chains break-up easily into two-celled fragments when mounted, (Fig. 11). Scopulariopsis brevicalvis produces nonseptate globose, subglobose or ovate spores in long chains. These spores are smooth or coarsely roughened hyaline to darkly pigmented, (Fig. 12). Papularia arundines is a saprophytic fungus and produces dark, oval, one-celled conidia, (Fig. 13).

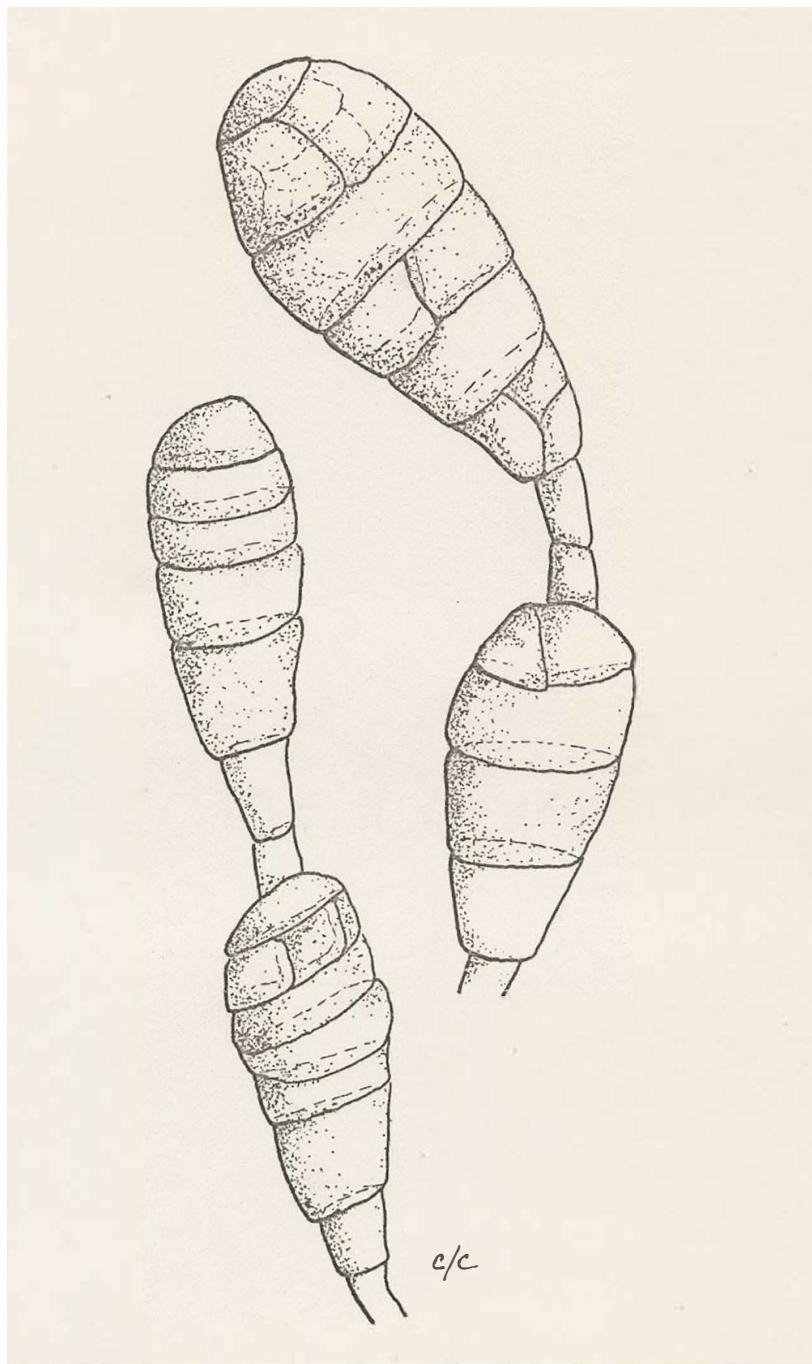


Fig. 9. Alternaria tenuis a potential plant pathogen



Fig. 10. Hormiscium sp. - a saprophytic fungus



Fig. 11. Cladosporium sphaerosporum - a saprophytic fungus



Fig. 12. Scopulariopsis brevicaulis - a saprophytic fungus

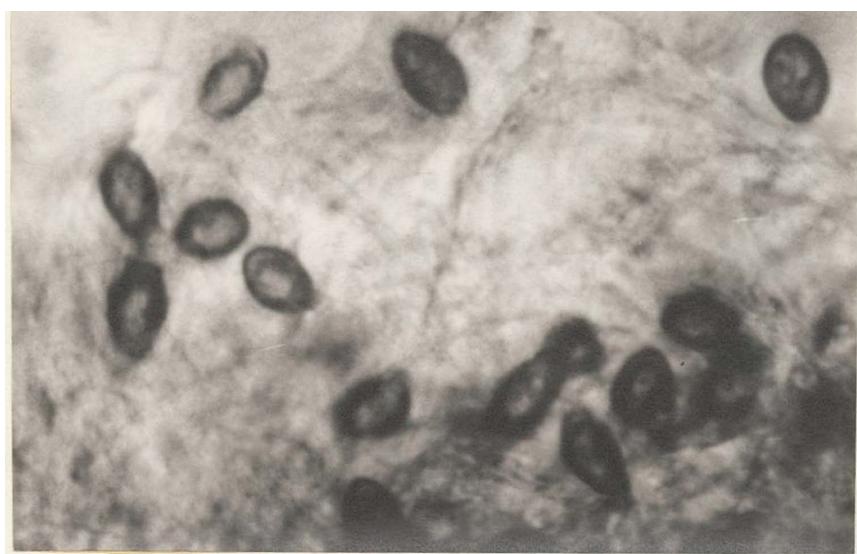


Fig. 13. Papularia arundinis - a saprophytic fungus

DISCUSSION

Methods

The dilution of samples was necessary in this study because of the large number of fungal spores present in the bottom sediments of Utah Lake. It was necessary to dilute these sediments to a 1/1,000 dilution to reduce the unidentifiable mass of fungal growth to 25 to 35 colonies per isolation plate. The water samples were not concentrated enough to require dilution before plating.

Taxonomic Considerations

The primary purpose of this study was to identify fungi imperfecti isolated from four locations in Utah Lake. It was necessary whenever possible to apply a systematic name to each fungus so that it might be recognized in a particular taxonomic group. Very few strains had characteristics exactly like the published description of each fungus. This problem was most acute in the Penicillia and Aspergilli which together included 43 different strains. The most serious problem connected with the identification of the Penicillia and Aspergilli is that so many of the choices in the key require the worker to make color comparisons and the dictionary of color by Maerz and Paul (1950) is an essential item in making these comparisons.

Relation of Fungi Imperfecti to the Percent Organic Matter

Fungi imperfecti were found in abundance throughout the study period from all study stations. The total number of fungal colonies at each station was in a direct relationship to the amount of organic matter present. Most fungi imperfecti exist in the lake as saprophytes, therefore, they obtain their carbon source from dead organic matter. The greatest amounts of organic matter present in the lake come from sources other than within the lake. These potential sources of organic matter are the effluent from sewage disposal units, from industry, and from fresh-water tributaries which contain wastes from agricultural and other practices. Additional organic matter from within the lake is due to the rapid extensive growths of algae and phytoplankton.

Mud Lake contained the largest number of fungi from the water and from the bottom sediments. A total of 107 species were isolated at that station. Of the 107 species from Mud Lake, 17 species were found only at that station. Mud Lake also contained the largest amounts of organic matter in the bottom sediments with an average of 9.4%. A total of 89 species were identified from the Spanish Fork River Station. The amount of organic matter present at the Spanish Fork River Station was 2.5%. Eighty-two species were isolated from the Provo River Station and 7 of these 82 species were found only at the Provo River Station. The amount of organic matter present at Provo River was 1.6%. Sixty species of fungi imperfecti were identified from the Jordan River Outlet and 6 of these

species were found only from that station. The amount of organic matter from the Jordan River Station was 0.8%. From the 138 species identified from this study, only nine species were found at all locations with 28 species found in three of the four stations. A decrease in the percent of organic matter was correlated with a decrease in the total number of fungi imperfecti present at a station and also in the number of fungi restricted to a particular station, (Table 6). The comparison of the number of fungal colonies present in the samples from the East and West side of the lake also demonstrate that the quantity of fungal growth is directly related to the amount of organic matter present.

The amount of organic matter present in the water at the study stations was not determined. Algal and phytoplanktic blooms were most abundant and in higher concentration at Mud Lake than at the other stations. Because the algae die and provide organic matter for fungal growth, it is believed that the organic matter is in higher concentration in the water at Mud Lake than at the other stations. This high content of organic matter in the water at Mud Lake is possibly the primary reason that the fungal concentrations in the water were higher at this station.

It is evident that in all forms of life the rate of growth and reproduction of an organism is in direct relationship to the one essential factor in the environment which is the most limited. Several factors may influence the rate of growth and reproduction of an organism, but all factors are related to the one essential factor which is most limited. If that one factor which is most

Table 6. Species distribution analyses of sample stations in comparison with the percentages of organic matter and clay.

Sample Stations	Location			Jordan River Outlet
	Spanish Fork River	Mud Lake	Provo River	
Total number of species	89	107	82	60
Number of species restricted to one location	16	17	7	6
Ranking of stations in relationship to percent organic matter	2 (2.5%)	1 (9.1%)	3 (1.6%)	4 (0.8%)
Ranking of stations in relationship to percent clay	4 (6.2%)	2 (14.1%)	3 (14.1%)	1 (74.8%)

limited is organic matter, then the rate of growth and reproduction of saprophytic fungi is directly dependent on the availability of this material.

Texture of Bottom Sediments

The percent sand, silt, and clay varied at all stations sampled, (Table 1). The Provo River, Mud Lake, and Spanish Fork River Stations were high in percentages of sand. The large sand particles are carried into the lake by the tributaries and the sand is the first soil particles to settle out of the water suspension. The Spanish Fork River and Pelican Point Stations bottom sediments are high in silt content. The Spanish Fork River sediment is high in the percent of parent material present in the water during the spring run-off season. This silt settles out of the water suspension and settles to the bottom of the lake. The Jordan River Outlet has a low percentage of sand and silt but contains a very high percent of clay. The clay particles are the last to settle out of the water suspension but the majority of the clay present is from the banks along the Jordan River Outlet. The banks are composed of deposits of clay which have settled out of the water suspension. In some way the clay content may influence fungal distribution as the lowest total number were found at stations high in clay content.

Relation of Fungi Imperfecti to the Hydrogen-Ion Concentration of the Water

The pH of all water samples was basic, ranging from a

low of 8.3 to a high of 8.8. Although the pH variation between study stations was low, there was a fluctuation in fungal characteristics. The primary reason for the variation in the pH at the different stations is that pH is affected by the action of photosynthetic algal activity. Intense photosynthesis raises the pH and reduces the bicarbonates in the water (Sundrud *et al.*, 1969). The fungi imperfecti were present in abundance in Utah Lake. Waksman (1944) suggested that fungi do best and are more likely to be found in acidic habitats, but the abundance of fungi imperfecti present in this study indicates that fungi are very diversified organisms and are tolerant to basic pH conditions.

Relationship of Fungi Imperfecti to Water Temperature

Variations occurred in surface and bottom water temperature at all study stations and for each date sampled. The trend in variation of the bottom and surface water temperature, was that it increased in the month of September.

The total number of fungi imperfecti cultured from the samples collected on June 19th, were lower in concentration than those cultured from other sample dates. The number of fungal colonies remained constant during the months of July, August and September, (Table 3). The temperature and the concentration of fungi imperfecti were low during the month of June. The temperature and fungal concentration both increased during the month of July and remained constant during the month of August. The temperature during the month of September decreased, but

the concentration of fungi imperfecti remained quite constant.

The variation in temperature did not relate directly to the number of fungi present. The low concentration of fungi during the month of June was possibly due to a shortage of organic matter and available nutrients. This opinion is based on the fact that simular temperatures were recorded in June and September, but a decrease in fungal concentration did not occur in September.

Occurrence of Fungi Imperfecti

Of the 138 species isolated from the water and from the bottom sediments of Utah Lake, 46 species occurred at only one station during the sampling period. Of these 46 species, 31 appeared only once throughout the sampling dates. By comparing the results from tables 3 and 6, the particular fungal flora of each study station can be established. This is accomplished, by comparing the frequency in which each fungus occurred and by determining the number of stations from which each fungus was isolated. The difference in the abundance of fungi at each station is possibly due to the available food and nutrient supply. Two possible explanations for the wide distribution of fungi imperfecti in the lake are, the frequent mixing of the water in Utah Lake and by the depositing of fungal spores in the water by wind action.

Role of Saprophytic Fungi

Most species of fungi imperfecti occur as saprophytes in the lake (Figs. 10, 11, 12, & 13). Saprophytic organisms in

general decompose organic matter and obtain their energy from this material. They then release carbon dioxide and water into the environment as the end product of this decomposition. The filamentous fungi, which live submerged in the water, may reduce the amounts of organic pollutants in the water. Fusarium oxy-sporium has been shown to decompose motor oil at the same rate that it decomposed organic matter from a sewage disposal unit (Cooke 1967). Such potential plant pathogenic organisms as Fusarium can be very benificial in the reduction of organic matter pollutants in the water. These fungi however, undergo asexual reproduction and release an abundance of spores into the water. If this water is then used for irrigation, serious economic losses could occur.

Although potential plant and animal pathogenic fungi were found it must be recognized that there are many fungal strains in each species of fungi. The fungi described as potential plant and animal pathogens might be non-pathogenic strains of these respective groups. The scope of this present study was not sufficiently broad as to demonstrate the actual pathogenisity of these fungal strains and taxonomic procedures alone are unable to clarify this aspect of a particular fungal strain.

SUMMARY AND CONCLUSIONS

1. Water and bottom sediment samples were collected from four stations in Utah Lake. These samples were taken at one month intervals to determine if changes occurred in water temperature, dissolved oxygen content, and hydrogen-ion concentration, and what effect these changes have on the fungal portion of the biota of Utah Lake.

2. The percent organic matter, sand, silt, and clay were determined for the bottom sediments of each sample station.

3. One hundred thirty-eight strains of fungi imperfecti were isolated from the water and from the bottom sediments. Six species of Aspergillus were isolated which are potential human and animal pathogens. Potential plant pathogens included 22 species of imperfect fungi. The presence of these fungi in Utah Lake does not necessarily mean that an outbreak in the disease caused by these fungi will occur.

4. A direct correlation existed between the total number of fungi isolated at each station and the percent of organic matter present. This correlation existed at all stations and for both water and bottom sediments. This correlation is a comparison of numbers of fungi at each station and the percent organic matter present at each station.

5. Variation in the water temperature and O_2 did not

effect the number of fungi present. The temperature range variation for surface water was 9.9°C while the total variation in bottom water temperature was 8.8°C over the four month period.

6. The total number of fungi imperfecti was much greater in the bottom sediments than in the water samples. These sediment samples were diluted with sterile distilled water to a dilution of 1/1,000. Growth of fungi from the water did not require dilution before the sample was plated.

7. The primary difference in the concentration of fungi at the various sample stations was due to the available nutrient supply and amounts of organic matter.

8. Potential pathogenic fungi in the water introduces the possibility of wide spread disease. The beneficial relationships of their presence in the water is that they help decompose the organic pollutants present in the water.

9. Fungal mycelia were not found in the water until samples were concentrated by centrifuging.

10. Procedures for futher study should include the use of several different types of nutrient media, including baiting of water samples. Futher studies should not be restricted to fungi imperfecti but should include all fungal organisms present in the water.

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TAXONOMY AND ECOLOGY OF FUNGI IMPERFECTI FROM FOUR
LOCATIONS IN UTAH LAKE, UTAH CO., UTAH

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ABSTRACT

Fungi imperfecti were cultured from water and bottom sediment samples collected at four locations of Utah Lake. These study sites included: (a) The mouth of Provo River, the largest fresh-water tributary entering Utah Lake, (b) Mud Lake, a large shallow area known for its high nitrogen content, (c) the entrance of the Spanish Fork River into the lake, a large fresh-water tributary containing wastes from industry and agricultural enterprises, (d) Jordan River, the only natural outlet of Utah Lake.

One hundred and thirty-eight species of fungi imperfecti were identified. A total of 89 species were isolated from the Spanish Fork River, 107 species from Mud Lake, 82 species from the Provo River, and 60 species from the Jordan River Outlet. Species that were restricted to a particular area included, 16 from the Spanish Fork River, 17 species from Mud Lake, 7 species from the Provo River and 6 from the Jordan River Outlet.

The total number of fungi cultured from each station was in a direct relationship to the percent organic matter present.

Seven species of Aspergillus which are potential human and animal pathogens were identified. Potential plant pathogenic fungi identified included 22 species.