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A study of aquatic fungi in Powell's slough

Chao-chih Hsiao
Brigham Young University - Provo

A STUDY OF AQUATIC FUNGI IN POWELL'S SLOUGH

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Chao-chih Hsiao

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INTRODUCTION

Statement of the Problem

Organisms lacking chlorophyll must, for the most part, depend ultimately upon the synthesizers for their existence. By far the greatest number of plants lacking chlorophyll belong in the fungi, a group which, though primarily terrestrial, has a number of aquatic representatives. These are for the most part Phycomycetes ("algae fungi") although the Myxomycetes, Ascomycetes, and Fungi Imperfecti all contain truly aquatic species.

The purpose of this investigation was to study some of the water fungi in Powell's Slough, a spring-fed slough which feeds into Utah Lake. The study was made in order to identify some of the common aquatic fungi found in the slough and to correlate the occurrence of these fungi with the environmental data from the slough.

Review of the Literature

An ecological study of the vegetation around Utah Lake by Cottam (1926) was the pioneer work on Powell's Slough. Barnett (1964) described the marsh habitat in Powell's Slough and analyzed the environmental factors that may influence the habitat.

Understanding of aquatic fungi is limited. Studies on aquatic fungi in desert areas are lacking. The only previous work on aquatic fungi in the state of Utah is that of Rooney (1967). However, this study was subalpine, and does not reflect study of lakes in so-called desert areas.

For other areas, Perrott (1960) discussed the composition of the Phycomycetes flora in a variety of freshwater habitats in North Staffordshire, Cheshire and South Wales, with a consideration of some of the environmental factors. From the sources that were available to the author, the only study concerned with seasonal changes of aquatic fungal species is that of Suzuki (1961), conducted in Japan. As far as identification is concerned, Sparrow (1960) gives the most complete classification on aquatic Phycomycetes.

Description of the Study Area

Powell's Slough is located on the east side of Utah Lake about two and one half miles north of Provo River in Township 6 South, Range 2 East, S.L.B&M., in parts of sections 19, 20, 29, and 30 (Fig. 1). The slough covers approximately 600 acres. It is fed by natural artesian springs and consists of a number of ponds and streams which eventually drain into Utah Lake.

Since the 1930's, Powell's Slough has been used increasingly as a pasture for livestock. Recently, some wet meadows were leveled and sown to grasses for hay & pasture.

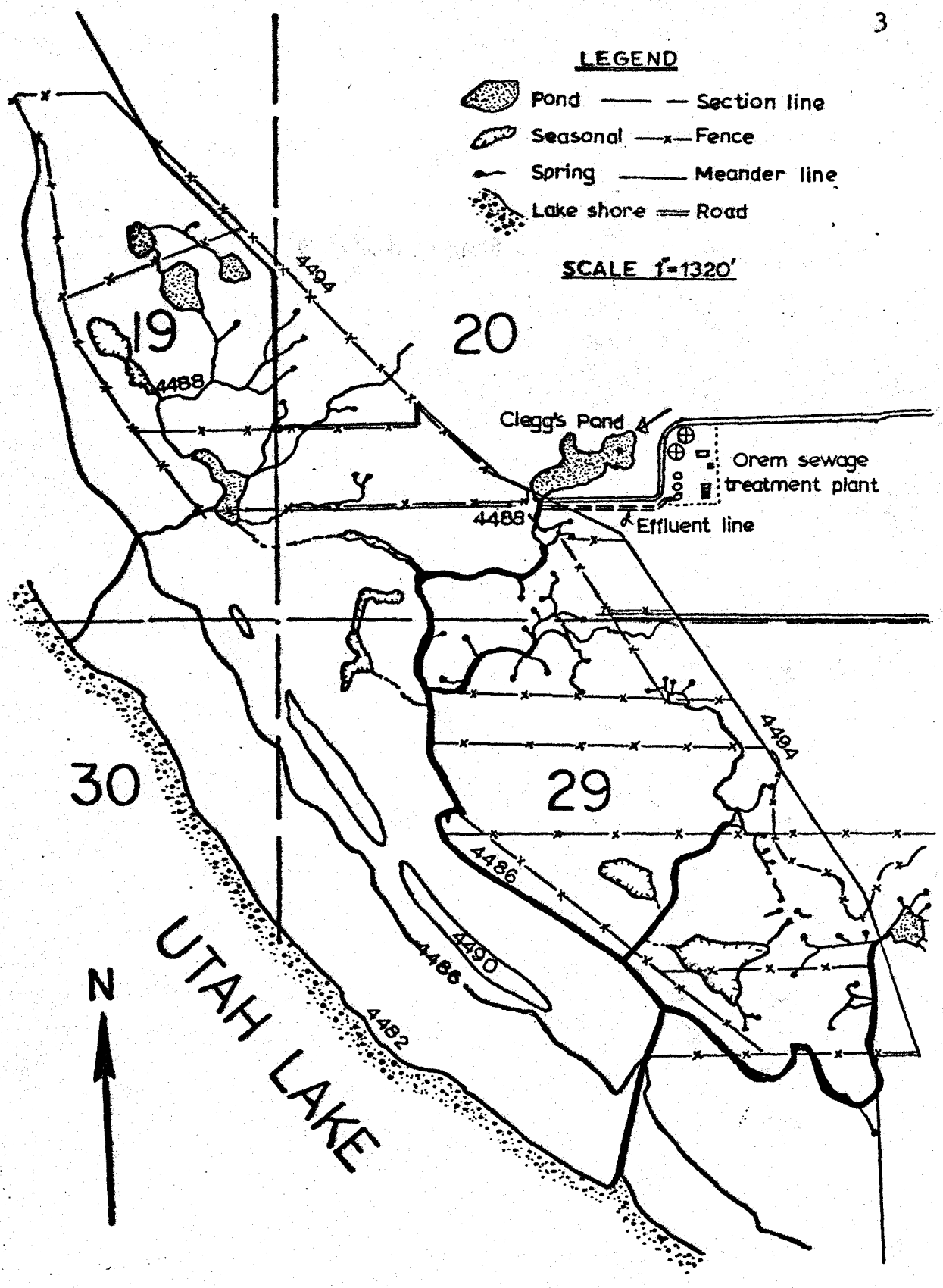

Fig. 1. Map of Powell's Slough

Fig. 2. Clegg's Pond — the head of Powell's Slough (May 10, 1968)

Note:

The picture was taken from the point indicated on Fig. 1. with the direction shown by the arrow.

Clegg's Pond (Fig. 2), the head of Powell's Slough, was chosen for this study. This pond is located at the N.E. corner of the slough and is in Section 20 (Fig. 1). It covers an area of 7 acres, with an average depth of about 3 to 6 feet. It has been suggested that the main sources of water in Clegg's Pond are Provo River, several springs, and drainage water from farms. Two study stations were established on Clegg's Pond. However, it was apparent during the course of this study that environmental conditions in the two stations were almost identical, thus the locations of these two stations were found unimportant to the results of this study.

Before 1959 most of the residents in the vicinity of Powell's Slough had private means of sewage disposal, but there is evidence that some raw sewage was being dumped into the slough. In 1959, a one million dollar sewage treatment plant was installed near Clegg's Pond. This plant was designed to remove about 90 per cent of the organic and bacterial pollution from the wastes of a population of 45,000 people (Orem Sewage Program, 1959). The effluent from this plant falls into the main stream of the slough immediately below the outlet of Clegg's Pond (Fig. 2), and flows thence into Utah Lake. The effect, if any, of the sewage disposal plant on the pond and the organisms found in it is not known.

METHODS AND MATERIALS

The great majority of water molds rarely appear in sufficient quantity in nature to be collected as one might obtain algae from a "bloom". Being either parasites or saprophytes, often with relatively specialized nutritional requirements, these fungi must be sought on particular hosts or substrata. Therefore a wide variety of substrata were used. The fifteen different types of substrata used in this study may be classified into three major groups as follows: (i) fruits: apples (Malus sp.), rose hips (Rosa sp.), plums (Prunus sp.), pears (Pyrus communis), haws (Crataegus mollis Scheele); (ii) twigs: poplar (Populus angustifolia James), weeping willow (Salix babylonica L.), river birch (Betula fontinalis Sarg.), weeping white birch (Betula pendula Roth var. Youngii), pine (Pinus sp.), sumac (Rhus glabra L.), roseleaf mountain ash (Sorbus aucuparia L.); (iii) others: algae, snake skin, fish head. The same substrata were used each time at each station.

At weekly intervals, wire baskets, each of which contained the above fifteen substrata were covered with gauze net and submerged in water of the slough at about one foot below the surface. These baskets, one at each station, were suspended from anchored Styrofoam floats. Environmental data

of the water were recorded at the same time the baskets were placed.

After the two baskets which first had been set out had been in place four weeks, they were collected and replaced with new baskets of substrata. In weekly rotation, these baskets of later date were collected after four weeks in position. After collections were made, the substrata from each basket were transferred to a plastic dish containing pond water. These two dishes were then brought into the laboratory. To reduce organisms not the concern of this study, substrata were washed carefully in tap water. Some fungal types are easily lost, so experimentation in washing as to method was necessary.

For some fungi, inspection under a dissecting scope was made first, then material was removed for more careful examination under the compound microscope. Materials were examined intensively as soon as possible after collection, since the changing environmental conditions generally induce quick zoospore production (Sparrow, 1960). For identification, Sparrow's (1960) keys were used. These keys are based upon the vegetatative morphological structures, upon the reproductive organs, and upon the activity of the zoospores. For any one collection, each species was listed as either present or absent. A record of occurrence might refer to a single thallus or to a great many thalli (Table 1).

Weekly measurements were taken of the following environmental factors: temperature, oxygen content, and pH value of the water. The water temperature and oxygen content were measured in the field with a Yellow Spring Instrument Model 51 Oxygen Meter. The pH value was measured in the laboratory with a Beckman Zeromatic ® pH Meter. The slough water was taken to the laboratory and pH was determined as quickly as possible.

The collections were made during the ice-free periods from 8 May 1967 until 17 November 1967, and from 24 March 1968 to 19 May 1968.

RESULTS

Thirty species of aquatic fungi were found from thirty-three collections of the fifteen types of substrata during the course of this study.

Classification of Species of Aquatic Fungi Found

The differences of opinion on fungal classification are numerous among mycologists. Sparrow's classification is the only one which gives enough detail to allow the proper determination of genera and species on aquatic fungi, so the author found it is necessary to follow Sparrow's new key in Aquatic Phycomycetes, 1960.

Order 1. Chytridiales
- Family 1. Olpidiaceae
  - Genus 1. Rozella
    - 1. blastocladiae
- Family 2. Megachytriaceae
  - Genus 1. Nowakowskiella
    - 1. ramosa

Order 2. Blastocladiales
- Family 1. Blastocladiaceae
  - Genus 1. Blastocladiella
    - 1. simplex
  - Genus 2. Blastocladiopsis
    - 1. parva
  - Genus 3. Blastocladia
    - 1. pringsheimii
    - 2. aspergilloides
    - 3. sparrowii
    - 4. globosa
    - 5. angusta

6. incrassata
7. rostrata
8. sp. #1
9. sp. #2
10. sp. #3

Order 3. Monoblepharidales
Family 1. Gonapodyaceae
Genus 1. Gonapodya
1. prolifera
2. polymorpha
3. sp.
Family 2. Monoblepharidaceae
Genus 1. Monoblepharis
1. hypogyna
2. macradra
3. ovigera

Order 4. Saprolegniales
Family 1. Saprolegniaceae
Genus 1. Saprolegnia
1. sp.
Genus 2. Dictyuchus
1. sterile

Order 5. Leptomitales
Family 1. Leptomitaceae
Genus 1. Leptomitus
1. lacteus
Genus 2. Apodachlya
1. brachynema

Order 6. Lagenidiales
Family 1. Lagenidiaceae
Genus 1. Myzocytium
1. proliferum

Order 7. Peronosporales
Family 1. Pythiaceae
Genus 1. Pythium
1. undulatum
2. sp.
Genus 2. Pythiogeton
1. ramosum
Genus 3. Phytophthora
1. megasperma
2. oryzae

Description of Species of Aquatic Fungi Found

CHYTRIDIALES

Olpidiaceae

Rozella blastocladiae (Minden) Sparrow

Thallus endobiotic, holocarpic; Sporangium assuming the shape of the hypertrophied host sporangium, which becomes somewhat broader and more ovoid than normal, with an apical pore, collapsing after discharge of the zoospores; zoospores not observed; resting spore spherical, thick-walled, the exospore densely covered with tenuous spines.

Parasitic in sporangia of Blastocladia pringsheimii, which was collected on apple in July of 1967.

Megachytriaceae

Nowakowskiella ramosa E. J. Butler

Rhizomycelium hyaline, richly-branched, tenuous portions 2-8 u in diameter. Sporangia terminal, smooth, spherical 40-55 u or oval 20x32 u, with one exit tube up to 100 u long. Opercula oval or circular in outline, 5 u in diameter. Resting spores spherical or slightly angular, 20-25 u, with numerous small refractive globules; wall 2 u thick, slightly verrucose.

Found on rotting stem of sumac, October of 1967.

BLASTOCLADIALES

Blastocladiaceae

Blastocladiella simplex Matthews

Basal cell cylindrical, holdfasts delicate, branched; whole thallus up to 1,000 u long by 20-35 u in diameter; sporangium cylindrical 45x100 u, wall thin, smooth, with one discharge papillae; resting spore globose, 120 u in diameter, surrounded by thin wall of the container, clavate, with a rounded apex and a truncate base.

Collected on apple in May and June of 1967.

Blastocladiopsis parva (Whiffen) Sparrow

Thallus about 280 u in length, dichotomously or subdichotomously branched; hyphae somewhat irregular; zoosporangia rare, terminal in the hyphae, irregular or somewhat cylindrical, 40-45 by 63-90 u; resting spore spherical, 56 u in diameter, wall smooth.

Collected on apples, pears, haws, and roseleaf mountain ash twigs, in June, October, and November of 1967 and in April of 1968.

Blastocladia pringsheimii Reinsch

Basal cell distinctly clavate, the branches, when formed, always clavate, holdfasts richly branched, the whole thallus up to 2,000 u long; sporangia borne along the tips of the branches or over the surface of the swollen lobes,

cylindrical or narrowly clavate, also fusiform, long ovoid, or siliquiform, usually at least four times as long as wide, not proliferating; zoospore spherical 14 u in diameter; resting spores borne among the sporangia, ovoidal or spherical with truncate base, 40-90 u long by 25-50 u in diameter, wall thick, punctate.

B. pringsheimii was the most common and abundant species found in Powell's Slough.

Forms dense pustules on apples, rose hips, plums, pears, and haws; on twigs of poplar, weeping willow, river birch, weeping white birch, pine, sumac, and roseleaf mountain ash. Collected throughout the entire period of this study.

Blastocladia aspergilloides Crooks

Plant cylindrical in the lower part, but expanded at the apex; branched forms were not observed; whole thallus only 150-400 u high, dark in color; sporangia cylindrical, 80-150 by 8-30 u; resting spores not observed. Generally regarded as a dwarf form of Blastocladia pringsheimii.

Collected on apples, rose hips, in August and October of 1967.

Blastocladia sparrowii Indoh

Basal cell clavate; sporangia proliferating, 20-40 by 80-120 u, zoospores spherical, 5 u in diameter; resting spores not observed.

Collected on apples, pears, and weeping willow twigs, during the entire period of collection.

Blastocladia globosa Kanouse

Basal cell globose, the cylindrical part very short or absent, holdfasts stout, much branched, whole thallus 200-300 u long by 220 u in diameter; sporangia cylindrical or broadly cylindrical, 70-180 u long by 22-70 u in diameter; resting spores subspherical or ovoidal, with truncate base, 35 by 50 u, wall thick, punctate.

Collected on apples, rose hips, plums, pears, and haws; on twigs of pine, river birch, weeping white birch, and sumac, throughout the entire period of collection.

Blastocladia angusta Lund

Basal cell cylindrical, distal part branched; sporangia borne at the tips of the branches, narrowly cylindrical about nine times as long as wide; resting spores broadly ovoid and beaked, 70 u long by 30 u wide, with truncate base, wall thin.

Collected on apples, rose hips, plums, and pears, in June, July, September, and November of 1967.

Blastocladia incrassata Indoh

Fungus-colony small, white, in compact tufts; basal body cylindrical, upper part closely branched in dichotomous or racemose manner; whole thallus 250-400 u long by 30 u wide; sporangia arranged racemosely or cymosely, 20 by 60 u, with truncate base; resting spores not observed.

Collected on apples and pears in June, July, September, October, and November of 1967, and in May of 1968.

Blastocladia rostrata Minden

Basal cell irregularly cylindrical, profusely branched and rebranched, cylindrical throughout; sporangia and the thick-walled brown resting spores appearing beaked.

Collected on apples, pears, sumac twigs, and pine twigs during the entire period of collection.

Blastocladia sp. #1

Basal cell unbranched, cylindrical in the lower part 21 u in diameter, but expanded at the apex to form a swollen head 40 u in diameter. Holdfasts richly branched, whole thallus 250-290 u high; sporangia small, spherical, cylindrical or irregular; resting spores not observed.

Collected on apples, pears, and weeping willow twigs, in July, August, September, and October of 1967.

Blastocladia sp. #2

Basal cell cylindrical, divided distally dichotomously or subdichotomously into tapering axes which branch and rebranch irregularly, holdfasts sparingly branched, whole thallus up to 1100 u in length; sporangia cylindrical or mostly irregular, 70-210 u long by 20-35 u in diameter, borne terminal and subterminal on irregular branches; resting spores spherical, 40 u in diameter. The branches of the basal cell very much like Blastocladia ramosa, but the spor-

angia not beaked.

Collected from apples in September of 1967, and in May of 1968.

Blastocladia sp. #3

Basal cell cylindrical, up to 600 u in length, wall rough, 7 u thick, distal portion with irregular lobes, which filled with many granules, whole thallus 450-650 u tall; sporangia broadly cylindrical 65 u long by 36 u in diameter, about two times as long as wide; resting spores ovoid, 44-56 by 32-40 u, with rounded apex and truncate base.

Collected on apples in June of 1967.

MONOBLEPHARIDALES

Gonapodyaceae

Gonapodya prolifera (Cornu) Fischer

Hyphae divided by pseudosepta into distinct segments; sporangia long siliqui form 44-60 u long by 22 u in diameter, once to many times proliferous; female gametangia elongate-ovoid, 120 by 60 u, with one discharge papilla; male gametangia smaller and slender than female, forming a single discharge papilla.

Collected on apples, rose hips, plums, pears, and sumac twigs, in June, July, September, and October of 1967, and in April and May of 1968.

Gonapodya polymorpha Thaxter

Hyphae obscurely segmented; sporangia ovoid, 64 u long by 40 u in diameter, once to many times proliferous; female gametangia short ovoid, usually with one to four discharge papillae.

Collected on rose hips and plums in July, September, and October of 1967, and in May of 1968.

Gonapodya sp.

Hyphae irregularly segmented, much wider than G. prolifera and G. polymorphae; sporangia 55-90 u long by 30-35 u in diameter, short ovoid or pod-shaped, once to two times proliferous; gametangia not observed.

Collected on apples in July of 1967.

Monoblepharidaceae

Monoblepharis hypogyna perrott

Hyphae cylindrical, branched and tapered toward the tip; sporangia cylindrical 95 u long by 6 u in diameter, borne singly in a terminal position; oogonia pyriform, occurring singly, 30 by 12 u; antheridia narrowly cylindrical, hypogynous.

Collected on apples in June, July, and August of 1967.

Monoblepharis macradra (Lagerheim) Woronin

Hyphae 5 u tapering distally to 2 u in diameter; sporangia narrowly cylindrical, occurring singly; oogonia pyriform 15-55 u by 6 u; antheridia conspicuously exserted,

in young plants occurring on separate branches from the oogonia, in older ones formed in groups with the oogonia.

Collected on apples and rose hips in June of 1967, and in March of 1968.

Monoblepharis ovigera Lagerheim

Mycelium well developed, 3-4 u in diameter; sporangia ovoid 30 u in length by 12 u in diameter, occurring singly; sexual reproduction not observed.

Collected on apples, pears, and haws in May, June, July, and October of 1967.

SAPROLEGNIALES

Saprolegniaceae

Saprolegnia sp

Growth rather delicate; gemmae abundant, size and shape very variable, often in chains; sporangia variable, but usually bent and irregular; sex organs absent.

Collected on apples and rose hips, weeping willow and poplar twigs, in June, July, August, and October of 1967, and in April and May of 1968.

Dictyuchus sterile Coker

Vegetative growth moderately stout, hyphae gradually tapering towards end; primary sporangia borne on the tips of hyphae, later ones formed by cymose branching; oogonia, antheridia, and gemmae not developed.

Collected on apples in October of 1967.

LEPTOMITALES

Leptomitaceae

Leptomitus lacteus (Roth) Agardh

Thallus filamentous throughout, conspicuously jointed and pseudoseptate; basal segment stout, 45 u in diameter; branches slender, 12 u in diameter; sporangia cylindrical, formed from slightly swollen segments of the mycelium; zoospores not observed; sex organs absent.

Collected on rose hips in October of 1967.

Apodachlya brachynema (Hildebrand) Pringsheim

Thallus filamentous throughout, richly branched; sporangia terminal, ovoid, 34-78 u long by 20-40 u in diameter, with a discharge papilla; oogonia spherical 24 u in diameter, borne singly at the tips of short moniliform segments; antheridium is the suboogonial cell.

Collected from plums in October of 1967 and April of 1968.

LEGENIDIALES

Lagenidiaceae

Myzocytium proliferum Schenk

Thallus endobiotic, holocarpic; sporangia in regular beadlike chains, broadly ellipsoidal, 15-25 u long by 10-15 u

wide, extramatrical part of the discharge tube narrowly cylindrical.

Parasitic in Spirogyra sp. in June of 1967.

PERONOSPORALES

Pythiaceae

Pythium undulatum Petersen

Thallus a richly branched hyphal complex; sporangia proliferating 50 by 30 u, borne at the tip of an unbranched, undulating sporangiophore, 6-8 u in diameter, which widen to 14 u immediately beneath sporangium; zoospores not observed; sex organ absent.

Collected on rose hips and plums in June, September, and October of 1967.

Pythium sp.

Mycelium well developed; sporangia proliferating, papillate, 100-120 u long by 20-30 u wide, borne terminal on irregular branches of sporangiophore; sex organs absent.

Collected from rose hips in July and October of 1967.

Pythiogeton ramosum Minden

Mycelium well developed, consisting of delicate, much-branched hyphae; sporangia narrowly bursiform, the discharge tube approximately at right angles to the axis of the supporting hyphae; sex organs unknown.

Collected on plums in September of 1967.

Phytophthora megasperma Drechsler

Mycelium composed of freely branching hyphae 7 u in diameter; sporangia nonpapillate, 40-50 u long by 20 u wide; oogonium spherical 50 u in diameter; antheridium in intimate contact with oogonial stalk.

Saprophytic on apples, rose hips, and plums, in August and September of 1967.

Phytophthora oryzae (Ito and Nagai) Waterhouse

Hyphae often swollen and knoblike at irregular intervals; sporangia ellipsoidal 70-85 u long by 28-34 u wide, later sporangia produced on the hyphae proliferated onwardly through the empty ones, or on the lateral branches; zoospores ellipsoidal 12 by 9 u, wrapped with vesicle-membrane; sex organs lacking.

Collected on apples, rose hips, and weeping white birch twigs, in July, August, November of 1967, and in March, May of 1968.

TABLE 1

SPECIES OCCURRENCE IN RELATION TO COLLECTION DATES

Species	Number of collection weeks 1 2 3 4 5 6 7 8 9 10 11										
	1967										
	May		Jun				Jul				
	8	15	1	8	17	24	4	12	18	24	30
Rozella blastocladiae											X
Nowakowskiella ramosa											
Blastocladiella simplex		X			X						
Blastocladiopsis parva				X	X						
Blastocladia pringsheimii	X	X	X	X	X	X	X	X	X	X	X
Blastocladia aspergilloides					X	X					
Blastocladia sparrowii	X	X	X		X						
Blastocladia globosa	X	X		X	X	X	X		X	X	X
Blastocladia angusta			X		X		X				
Blastocladia incrassata				X	X	X	X			X	X
Blastocladia rostrata	X		X	X		X	X	X	X		
Blastocladia sp. #1								X			
Blastocladia sp. #2											
Blastocladia sp. #3						X					
Gonapodya prolifera				X	X		X	X	X		X
Gonapodya polymorpha							X	X			
Gonapodya sp											X
Monoblepharis hypogyna				X						X	X
Monoblepharis macradra					X						
Monoblepharis ovigera		X				X		X			
Saprolegnia sp			X	X	X				X		
Dictyuchus sterile											
Leptomitus lacteus											
Apodachlya brachynema											
Myzocytium proliferum			X								
Pythium undulatum						X					
Pythium sp									X		
Pythiogeton ramosum											
Phytophthora megasperma											
Phytophthora oryzae										X	
No. of species collected per week	4	5	6	8	11	8	7	6	6	5	7

TABLE 1 Continued

SPECIES OCCURRENCE IN RELATION TO COLLECTION DATES

Species	Number of collection weeks 12 13 14 15 16 17 18 19							
	1967							
	Aug				Sep			
	7	14	21	27	4	11	18	26
Rozella blastocladiae								
Nowakowskiella ramosa								
Blastocladiella simplex								
Blastocladiopsis parva								
Blastocladia pringsheimii	X	X	X	X	X	X	X	X
Blastocladia aspergilloides				X				
Blastocladia sparrowii	X						X	X
Blastocladia globosa	X	X		X	X	X	X	X
Blastocladia angusta							X	X
Blastocladia incrassata						X	X	
Blastocladia rostrata		X	X		X	X	X	X
Blastocladia sp. #1	X		X			X	X	
Blastocladia sp. #2					X			X
Blastocladia sp. #3								
Gonapodya prolifera					X	X		X
Gonapodya polymorpha								X
Gonapodya sp								
Monoblepharis hypogyna		X						
Monoblepharis macradra								
Monoblepharis ovigera								
Saprolegnia sp	X			X				
Dictyuchus sterile								
Leptomitus lacteus								
Apodachlya brachynema								
Myzocytium proliferum								
Pythium undulatum					X			
Pythium sp								
Pythiogeton ramosum					X			
Phytophthora megasperma			X					X
Phytophthora oryzae			X					
No. of species collected per week	5	4	5	4	7	6	7	9

TABLE 1 Continued

SPECIES OCCURRENCE IN RELATION TO COLLECTION DATES

Species	Number of collection weeks								
	20	21	22	23	24	25	26	27	28
	1967							1968	
	Oct				Nov			Mar	
	1	8	15	28	3	10	17	17	24
Rozella blastocladiae									
Nowakowskiella ramosa	X								
Blastocladiella simplex									
Blastocladiopsis parva			X	X			X		
Blastocladia pringsheimii	X	X	X	X	X	X	X	X	X
Blastocladia aspergilloides	X	X							
Blastocladia sparrowii	X		X	X		X	X	X	
Blastocladia globosa	X	X	X	X	X	X	X	X	X
Blastocladia angusta							X		
Blastocladia incrassata	X	X	X		X	X	X		
Blastocladia rostrata	X	X	X				X		X
Blastocladia sp. #1		X							
Blastocladia sp. #2									
Blastocladia sp. #3									
Gonapodya prolifera	X	X	X	X					
Gonapodya polymorpha	X		X						
Gonapodya sp									
Monoblepharis hypogyna									
Monoblepharis macradra									X
Monoblepharis ovigera				X					
Saprolegnia sp	X	X	X						
Dictyuchus sterile		X							
Leptomitus lacteus		X							
Apodachlya brachynema		X	X						
Myzocytium proliferum									
Pythium undulatum	X	X							
Pythium sp	X	X							
Pythiogeton ramosum									
Phytophthora megasperma									
Phytophthora oryzae					X			X	X
No. of species collected per week	11	14	10	6	4	4	7	4	5

TABLE 1 Continued

SPECIES OCCURRENCE IN RELATION TO COLLECTION DATES

Species	No. of col. wks. 29 30 31 32 33 — 1968 — Apr 21 28	May 3 10 19	Total Records	Percentage Occurrence
Rozella blastocladiae		X	2	6
Nowakowskiella ramosa		X	2	6
Blastocladiella simplex			2	6
Blastocladiopsis parva	X		6	18
Blastocladia pringsheimii	X X	X X X	33	100
Blastocladia aspergilloides	X	X X	8	24
Blastocladia sparrowii		X	14	42
Blastocladia globosa	X X	X X X	30	91
Blastocladia angusta			6	18
Blastocladia incrassata		X X X	17	52
Blastocladia rostrata	X	X X X	22	67
Blastocladia sp. #1			6	18
Blastocladia sp. #2		X X	4	12
Blastocladia sp. #3			1	3
Gonapodya prolifera	X	X X X	17	52
Gonapodya polymorpha		X	6	18
Gonapodya sp			1	3
Monoblepharis hypogyna			4	12
Monoblepharis macradra			2	6
Monoblepharis ovigera			4	12
Saprolegnia sp	X	X	11	33
Dictyuchus sterile			1	3
Leptomitus lacteus			1	3
Apodachlya brachynema	X		3	9
Myzocytium proliferum			1	3
Pythium undulatum			4	12
Pythium sp			3	9
Pythiogeton ramosum			1	3
Phytophthora megasperma			2	6
Phytophthora oryzae		X X	7	21
No. of species collected per week	5 5	8 8 10		

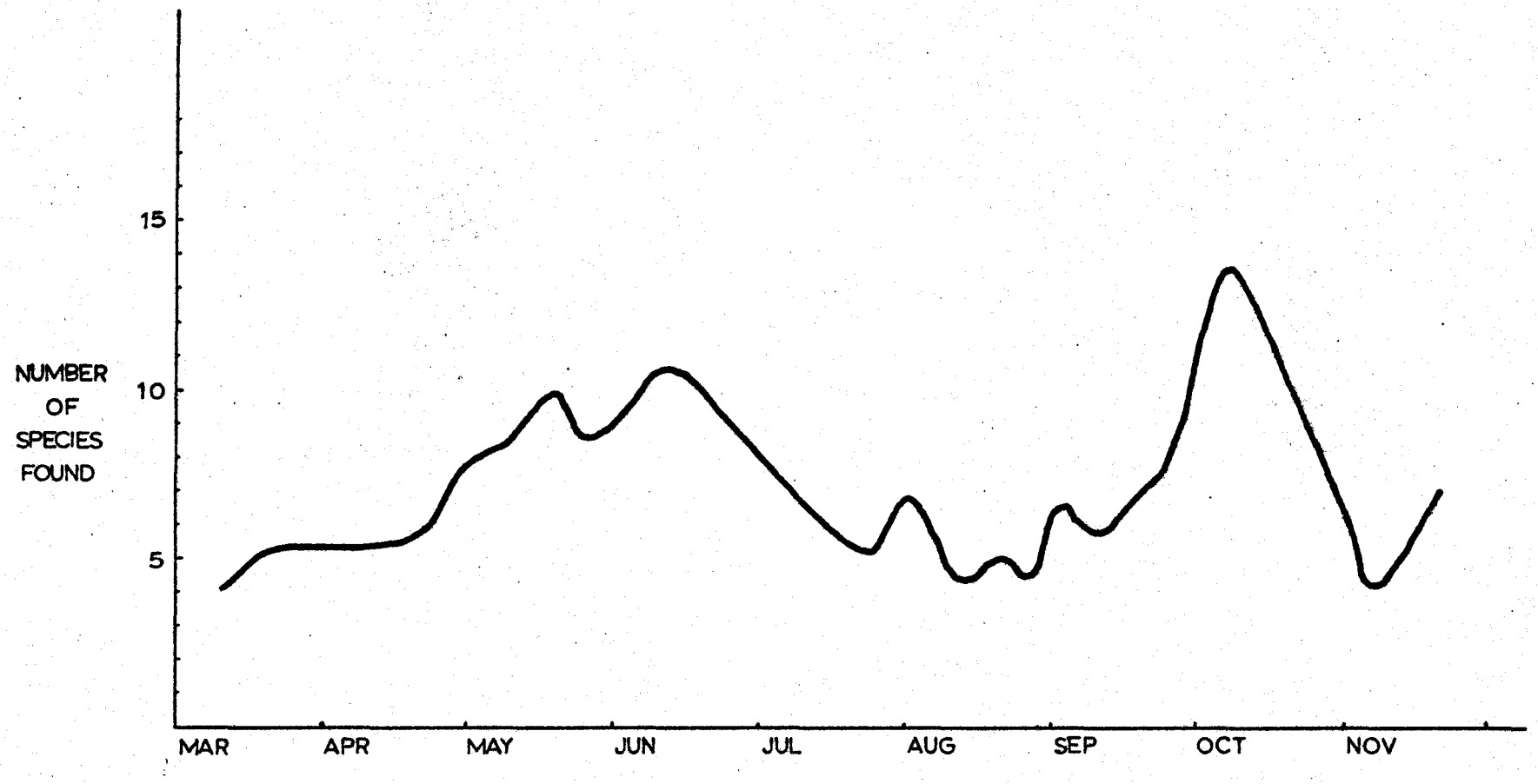

FIG. 3. SEASONAL DISTRIBUTION OF AQUATIC FUNGI IN POWELL'S SLOUGH

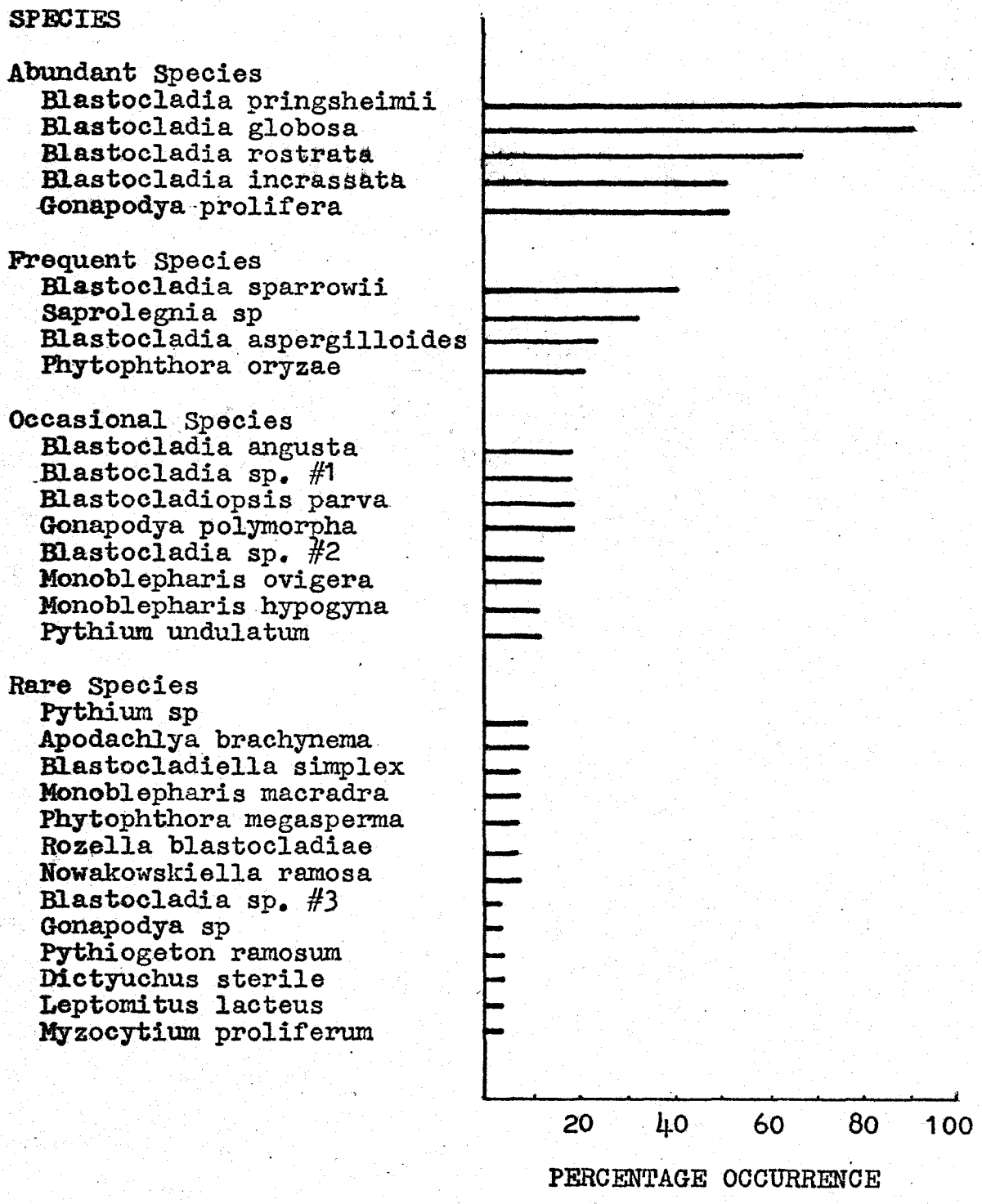

Fig. 4. Degrees of abundance of species found.

Fig. 3, which shows the seasonal distribution of aquatic fungi in Powell's Slough was derived from Table 1. Greater number of species were found in May, June, September, and October, than in the other months of the year (Fig. 3), e.g., the number of species found increased both in spring and autumn, and decreased in summer. (No data were taken nor were collections made during the winter months.)

The percentage occurrence of each species calculated from thirty-three collections is reported (Table 1). On the basis of their percentage occurrence, each of the aquatic fungi is placed in one of four groups: (i) abundant, with a percentage occurrence between 52% - 100%; (ii) frequent, 21% - 42%; (iii) occassional, 12% - 18%; (iv) rare, 3% - 9%.

Correlation Between Fungal Species and Substrata

The relationship between aquatic fungi found and the substrata used is given in Tables 2 and 3.

TABLE 2

AQUATIC FUNGI IN POWELL'S SLOUGH AND THE SUBSTRATA ON WHICH THEY WERE FOUND

Species	Substrata
Chytridiales	
Olpidiaceae	
Rozella blastocladiae (Minden) Sparrow	*Blastocladia pringsheimii* (apple)
Megachytriaceae	
Nowakowskiella ramosa E.J. Butler	sumac twigs
Blastocladiales	
Blastocladiaceae	
Blastocladiella simplex Matthews	apples
Blastocladiopsis parva (Whiffen) Sparrow	apples, pears, haws, roseleaf mountain ash twigs
Blastocladia pringsheimii Reinsch	apples, rose hips, plums, pears, haws; poplar twigs, weeping willow twigs, river birch twigs, weeping white birch twigs, pine twigs, sumac twigs, roseleaf mountain ash twigs
Blastocladia aspergilloides Crooks	apples, rose hips
Blastocladia sparrowii Indoh	apples, pears, weeping willow twigs

TABLE 2--Continued

Species	Substrata
Blastocladia globosa Kanouse	apples, rose hips, plums, pears, haws, pine twigs, river birch twigs, weeping white birch twigs, sumac twigs
Blastocladia angusta Lund	apples, rose hips, plums, pears
Blastocladia incrassata Indoh	apples, pears
Blastocladia rostrata Minden	apples, pears, sumac twigs, pine twigs
Blastocladia sp. #1	apples, pears, weeping willow twigs
Blastocladia sp. #2	apples
Blastocladia sp. #3	apples
Monoblepharidales	
Gonapodyaceae	
Gonapodya prolifera (Cornu) Fischer	apples, rose hips, plums, pears, sumac twigs
Gonapodya polymorpha Thaxter	rose hips, plums
Gonapodya sp.	apples
Monoblepharidaceae	
Monoblepharis hypogyna Perrott	apples
Monoblepharis macradra (Lagerheim) Woronin . .	apples, rose hips
Monoblepharis ovigera Lagerheim	apples, pears, haws, poplar twigs

TABLE 2--Continued

Species	Substrata
Saprolegniales	
Saprolegniaceae	
Saprolegnia sp	apples, rose hips, poplar twigs, weeping willow twigs
Dictyuchus sterile Coker	apples
Leptomitales	
Leptomitaceae	
Leptomitus lacteus (Roth) Agardh	rose hips
Apodachlya brachynema (Hildebrand) Pringsheim	plums, apples
Lagenidiales	
Lagenidiaceae	
Myzocytium proliferum Schenk	algae (*Spirogyra* sp.)
Peronosporales	
Pythiaceae	
Pythium undulatum Petersen	rose hips, plums
Pythium sp	rose hips
Pythiogeton ramosum Minden	plums
Phytophthora megasperma Drechsler	apples, rose hips, plums
Phytophythora oryzae (Ito and Nagai) Waterhouse	apples, rose hips, weeping white birch twigs

TABLE 3

LIST OF SUBSTRATA AND THE CORRESPONDING AQUATIC FUNGI FOUND

Substrata	Fungal Species
apples (*Malus* sp)	*Rozella blastocladiae* *Blastocladiella simplex* *Blastocladiopsis parva* *Blastocladia pringsheimii* *Blastocladia aspergilloides* *Blastocladia sparrowii* *Blastocladia globosa* *Blastocladia angusta* *Blastocladia incrassata* *Blastocladia rostrata* *Blastocladia* sp. #1 *Blastocladia* sp. #2 *Blastocladia* sp. #3 *Gonapodya prolifera* *Gonapodya* sp *Monoblepharis hypogyna* *Monoblepharis macradra* *Monoblepharis ovigera* *Saprolegnia* sp *Dictyuchus sterile* *Apodachlya brachynema* *Phytophthora oryzae*
rose hips (*Rosa* sp)	*Blastocladia pringsheimii* *Blastocladia aspergilloides* *Blastocladia globosa* *Blastocladia angusta* *Gonapodya prolifera* *Monoblepharis macradra* *Saprolegnia* sp *Leptomitus lacteus* *Pythium undulatum* *Pythium* sp *Phytophthora megasperma* *Phytophthora oryzae*

TABLE 3--Continued

Substrata	Fungal Species
plums (*Prunus* sp)	*Blastocladia pringsheimii* *Blastocladia globosa* *Blastocladia angusta* *Gonapodya prolifera* *Gonapodya polymorpha* *Apodachlya brachynema* *Pythium undulatum* *Pythiogeton ramosum* *Phytophthora megasperma*
pears (*Pyrus communis*). . . .	*Blastocladiopsis parva* *Blastocladia pringsheimii* *Blastocladia sparrowii* *Blastocladia globosa* *Blastocladia angusta* *Blastocladia incrassata* *Blastocladia rostrata* *Blastocladia* sp. #1 *Gonapodya prolifera* *Monoblepharis ovigera*
haws (*Crataegus mollis* Scheele). .	*Blastocladia pringsheimii* *Blastocladia globosa* *Monoblepharis ovigera*
poplar twigs (*Populus angustifolia* James).	*Blastocladiopsis parva* *Blastocladia pringsheimii* *Monoblepharis ovigera* *Saprolegnia* sp
weeping willow twigs (*Salix babylonica* L.)	*Blastocladia pringsheimii* *Blastocladia sparrowii* *Blastocladia globosa* *Blastocladia* sp. #1 *Saprolegnia* sp

TABLE 3--Continued

Substrata	Fungal Species
river birch twigs (*Betula fontinalis* Sarg.)	*Blastocladia pringsheimii* *Blastocladia globosa*
weeping white birch twigs (*Betula pendula* Roth var. Youngii)	*Blastocladia pringsheimii* *Blastocladia globosa* *Phytophthora oryzae*
pine twigs (*Pinus* sp)	*Blastocladia pringsheimii* *Blastocladia globosa* *Blastocladia rostrata*
sumac twigs (*Rhus glabra* L.)	*Nowakowskiella ramosa* *Blastocladia pringsheimii* *Blastocladia globosa* *Blastocladia rostrata* *Gonapodya prolifera*
rose leaf mountain ash twigs (*Sorbus aucuparia* L.)	*Blastocladiopsis parva* *Blastocladia pringsheimii*
algae (*Spirogyra* sp)	*Myzocytium proliferum*

Environmental Data

The following environmental information was summarized from Table 4:

Water temperature °C	8.5°C - 23.5°C
pH of water	7.7 - 8.1
Dissolved oxygen ppm	3.0 - 8.2

TABLE 4

WEEKLY ENVIRONMENTAL DATA ON POWELL'S SLOUGH

Date	Water Temp. °C	Water pH	Dissolved Oxygen ppm
5- 8-1967	17.0	-	-
5-15-1967	21.0	-	-
6- 1-1967	18.0	-	-
6- 8-1967	18.0	7.9	-
6-17-1967	12.5	7.8	-
6-24-1967	20.0	7.7	-
7- 4-1967	22.5	7.8	-
7-12-1967	20.0	7.7	-
7-18-1967	21.0	7.8	-
7-24-1967	19.5	7.8	3.0
7-30-1967	23.5	7.8	2.5
8- 7-1967	22.0	7.7	3.0
8-14-1967	21.0	7.8	3.5
8-21-1967	19.0	7.8	5.0
8-27-1967	18.0	7.8	6.5
9- 4-1967	15.0	8.1	6.5
9-11-1967	15.0	7.8	6.0
9-18-1967	15.0	7.8	7.5
9-26-1967	14.5	7.9	7.6
10- 1-1967	14.5	7.7	7.6
10- 8-1967	12.5	8.0	8.0
10-15-1967	12.0	7.8	8.0
10-28-1967	9.5	7.8	-
11- 3-1967	8.5	7.9	-
11-10-1967	10.5	7.8	-
11-17-1967	10.5	7.9	-
3-17-1968	9.0	7.9	-
3-24-1968	10.0	7.9	-
4-21-1968	11.3	7.8	8.2
4-28-1968	12.5	7.9	7.9
5- 3-1968	12.0	7.9	8.2
5-10-1968	17.0	7.8	7.5
5-19-1968	17.5	7.8	7.9

- Dates instruments not available.

DISCUSSION

Aquatic fungi occur on a wide variety of substrata in water. Probably the only limiting factors are inimical physical conditions and lack of suitable substrata (Sparrow,1960).

Seven orders-- Chytridiales, Blastocladiales, Monoblepharidales, Saprolegniales, Leptomitales, Lagenidiales, and Peronosporales, were found during this investigation. The occurrence of each order is discussed as follows:

Members of the Chytridiales were found as saprophytes or parasites on diverse hosts. Two species, Rozella blastocladiae and Nowakowskiella ramosa were collected from Powell's Slough. These two species were in the group which was rarely found. According to Sparrow (1960), many chytrids have been discovered through the use of substances of animal origin such as purified shrimp chitin and various forms of keratin (snake-skin casts, defatted hair and skin, horn shaving and the like). However, no chytrids were found on materials from animal origin throughout the entire investigation. This lack of observation might have been due to the small size of many chytrids and consequent failure to see them, rather than to lack of occurrence.

The Blastocladiales were primarily found as saprophytes. They occurred most commonly on various kind of fruits

and twigs. On these submerged substrata, this group formed white hemispherical pustules of densely compacted plants. These white pustules always grew on the lenticels of the rough surfaces of the fruits and twigs. Among the twelve species collected in the Blastocladiales, four species in the genus Blastocladia occurred more often than any other species in this study. These four species were B. pringsheimii, B. globosa, B. rostrata, and B. incrassata. They formed the major species in the abundant group. Blastocladia pringsheimii was the most abundant species with a percentage occurrence of 100 per cent. Apples were found to be the best substrata for the growth of Blastocladiales.

The Saprolegniales, Leptomitales, and Peronosporales, are similar to Blastocladiales in occurrence. In the Saprolegniales, two species were recorded: (i) Saprolegnia sp.; and (ii) Dictyuchus sterile. Saprolegnia sp. was a frequently occurring species. The two species collected in the order Leptomitales were rare species (Fig. 4). In the Peronosporales only Phytophthora oryzae was a frequently occurring species. The other four species collected in this order were in the occasionally and rarely occurring groups (Fig.4).

In the Lagenidiales only one species, Myzocytium proliferum, was recorded. It was a rarely occurring species, found as a parasite on Spirogyra sp.

The Monoblepharidales were usually found on sunden twigs and fruits in cool water. Perrott (1960) indicated

that Monoblepharidales were rarely found on substrata brought in from the field and immediately subjected to examination. If, however, such substrata were placed in a refrigerator at 3°C for a few days, the fungus, if it was present on the substrata, would often by then have produced an abundance of growth. This was true also in this study. The six species collected from this order were collected in this manner. Gonapodya prolifera had a percentage occurrence of 52 per cent. The other five species of the Monoblepharidales occurred in the occasional and rare groups.

Of the fifteen types of substrata used (Table 3), fish heads proved to be unsuccessful as baits, perhaps because of competition by bacteria. Such material were always heavily colonized by bacteria. Under such conditions, the growth of even the more rapidly growing fungi was checked and sexual reproductive organs were rarely formed.

Mycelical growth was never found on snake skin in this study, although snake skin worked well for Rooney (1967) in Lily Lake.

Fruits proved to be successful as baits, especially when firm and slightly underripe. The substrata which produced the greatest number of different fungi were apples and rose hips.

It is possible that the crevices and openings on the surface of substrata provided good anchorage and protection for zoospores (Perrott, 1960). In fact the reproductive

branches of many aquatic fungi grow out from the lenticels. Therefore, it was desirable that the water at collection stations should be relatively free from suspended silt, which tends to fill up the openings when present.

The aquatic fungi in Powell's Slough showed remarkable seasonal changes (Table 1, Fig. 3 and Fig. 7). The following are the interactions between the environmental condition and variation of aquatic fungi in Powell's Slough.

There was no great fluctuation in the pH range of the slough during the entire period of this study (Table 4). Therefore, there was no indication that pH affected the species occurrence.

A greater number of species were found in May, June, September, and October, than in the other months of the year (Fig. 3). That is, the number of species collected increased both in spring and autumn while the temperature ranged between 12°C and 17°C. Temperatures below 12°C, however, were found not suitable for the growth of some aquatic fungi (Fig. 5 & Fig. 7). Also temperatures above 17°C seemed to adversely affect some species (Fig. 5 & Fig. 7).

The information of the oxygen content was not complete due to a great number of dates when instruments were not available. However, the oxygen content was found to be inversely proportional to the water temperature, e.g., when the water temperature increases, the oxygen content decreases (Fig. 6).

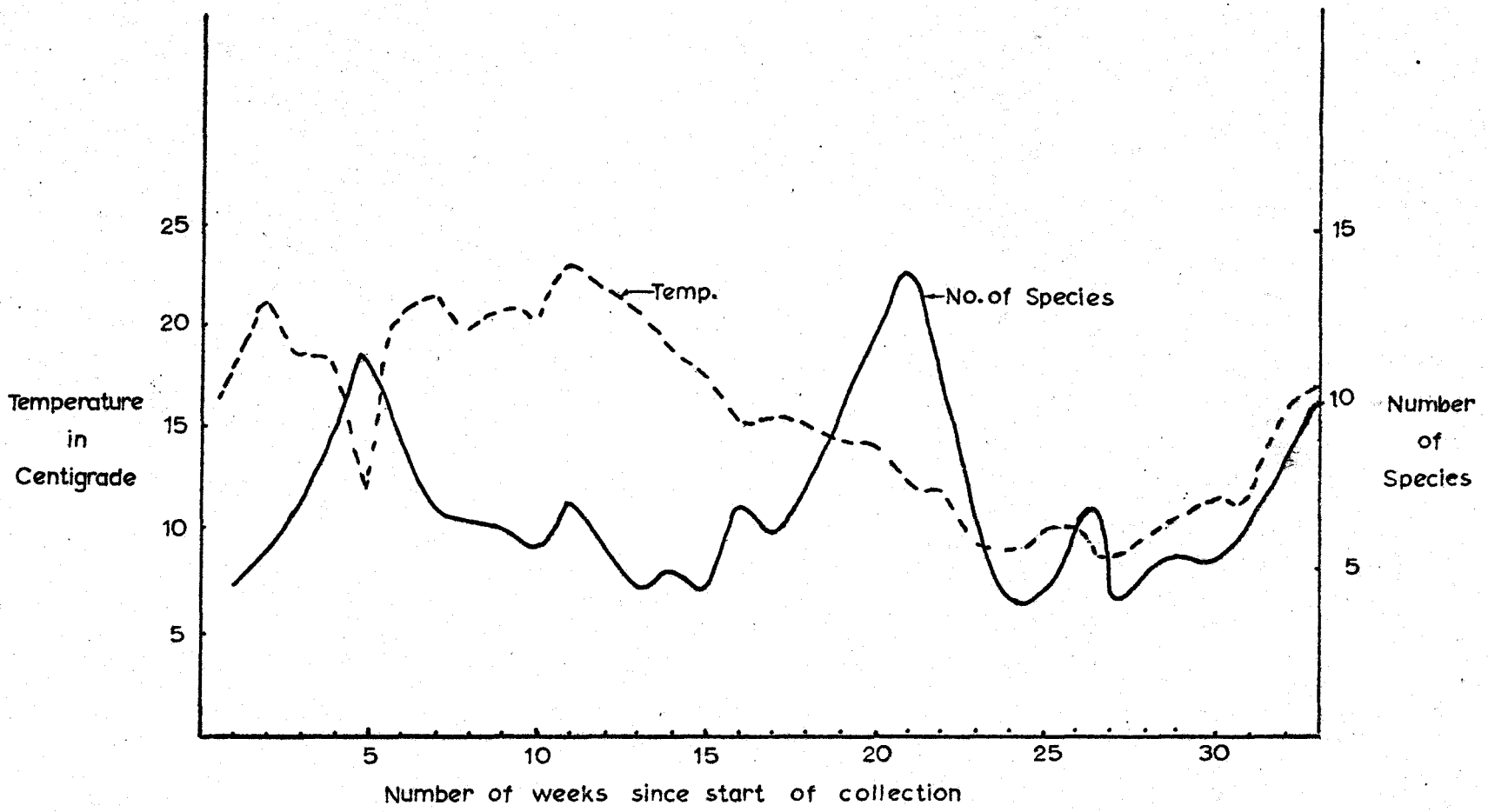

Fig. 5. The water temperature in relation to the number of species collected each week.

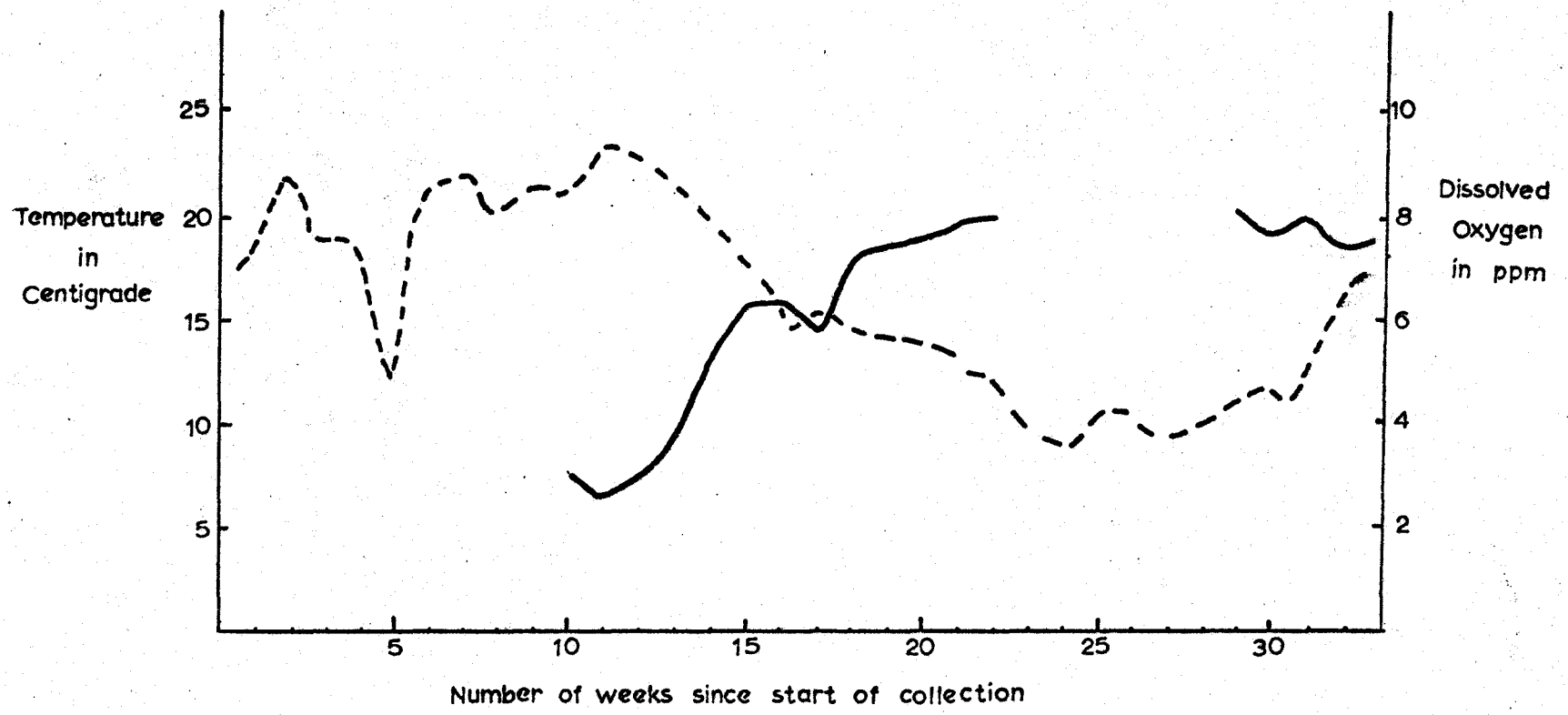

Fig. 6. The fluctuation of water temperature and oxygen content

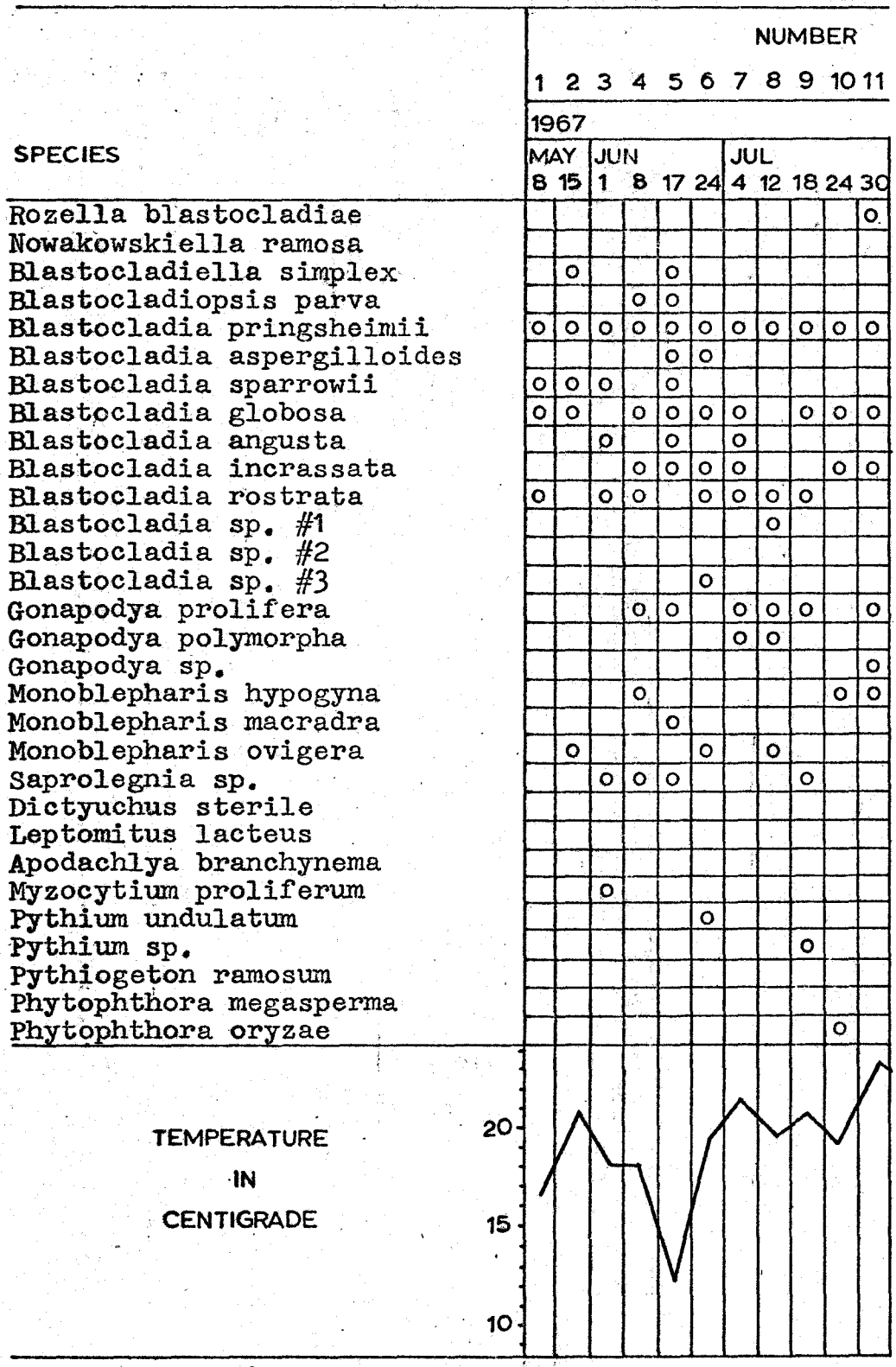

FIG. 7. SPECIES OCCURRENCE IN RELATION TO WATER TEMPERATURE

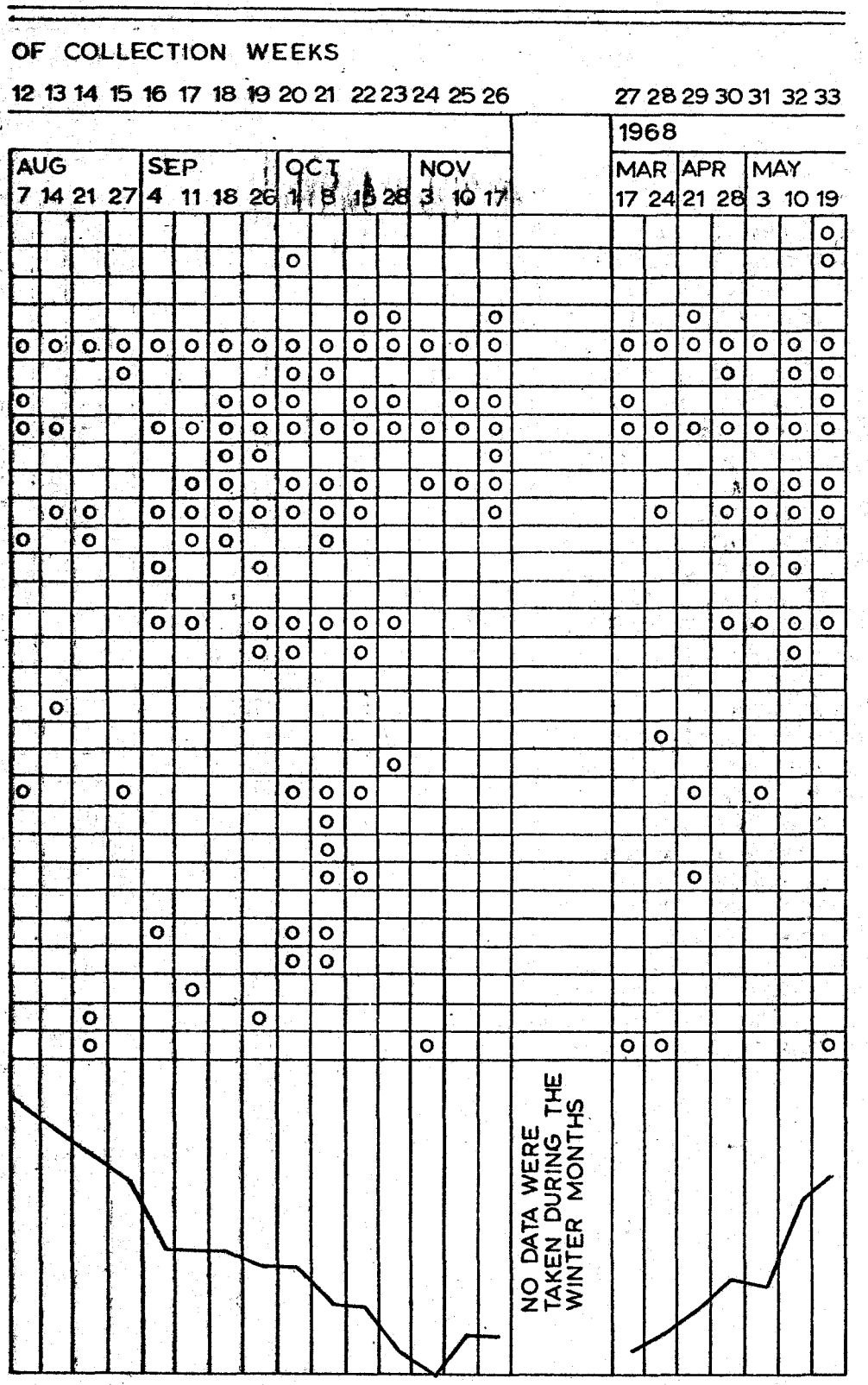

FIG. 7. CONTINUED

According to this study, the main factors which seemed to affect the occurrence of aquatic fungi in Powell's Slough were types of substrata used, water temperature, and oxygen content.

From observation, however, large populations of bacteria affected growth of fungi, but no specific pertinent data were gathered. Also, one cannot exclude the time factor required for maturation of resting spores as of concern for such study.

SUMMARY

1. The purpose of this thesis was to make a study of the aquatic fungi in Powell's Slough. Aquatic fungi were collected from May 8 to November 17, 1967, and from March 17 to May 19, 1968.

2. The pH of the water in Powell's Slough is slightly alkaline, with an average pH of 7.9, and a range of 7.7 to 8.1.

3. Fifteen types of substrata were used in this study: apples, rose hips, plums, pears, haws; twigs of poplar, weeping willow, river birch, weeping white birch, pine, sumac, roseleaf mountain ash; algae, snake skin, and fish head.

4. Representation of seven orders, nine families, fifteen genera, and thirty species of aquatic fungi were found in Powell's Slough during this study.

5. Blastocladia was the predominant genus in Powell's Slough. Among all the species in this genus, Blastocladia pringsheimii was the most abundant species with a percentage occurrence of 100 per cent, and was found on twelve different types of substrata.

6. Snake skin and fish head were the only two

unsuccessful substrata. Aquatic fungi were never found on these two substrata throughout the entire study, while apples were the most successful substratum, and allowed growth of twenty-two different species of aquatic fungi.

7. The number of species found increased both in spring and autumn while the temperatures ranged between 12°C and 17°C, and decreased in summer when temperatures rose above 17°C.

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ABSTRACT

Aquatic fungi in Powell's Slough were studied in 1967 & 1968.

Collections were made and water temperature, oxygen content & pH values were measured at weekly intervals. For collections, wire baskets containing substrata were submerged in water for one month. After collecting, substrata were brought to the laboratory. Identification was based on the keys of Sparrow, 1960.

Aquatic fungi identified included seven orders, nine families, fifteen genera, and thirty species, from thirty-three collections of fifteen types of substrata.

The substrata used in this study were: (i) fruits: apples, rose hips, plums, pears, haws; (ii) twigs: poplar, weeping willow, river birch, weeping white birch, pine, sumac, roseleaf mountain ash; (iii) others: algae, snake skin, fish head.

Blastocladia pringsheimii was the predominant species, found on twelve different types of substrata.

The number of species increased both in spring and in autumn, and decreased in summer.