TAXONOMY AND DISTRIBUTION OF FUNGI ISOLATED FROM BEACH RIDGE AND MARSH SOIL AT DELTA, MANITOBA

A Thesis

Submitted to

The Faculty of Graduate Studies

University of Manitoba

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Joseph William Pearn

October, 1981

TAXONOMY AND DISTRIBUTION OF FUNGI ISOLATED FROM BEACH RIDGE AND MARSH SOIL AT DELTA, MANITOBA

BY

JOSEPH WILLIAM PEARN

A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

For Gloria

Friend
Lover
Mother

ABSTRACT

Fungi were isolated from the 0-30 cm profile of beach ridge soil and the 0-10 cm profile of marsh soil, Delta Marsh, Manitoba. A soil washing technique followed by dilution plating on four different culture media each at four different incubation temperatures, was employed to maximize the range of fungi recovered.

A combined total of 109 species from 43 genera of fungi, were isolated. Thirty-nine of 81 beach ridge fungi and 28 of 68 marsh species were site specific; the remaining 42 species were common to both soils.

A large proportion of the fungi isolated belong within eight predominant genera; Acremonium (Cephalosporium), Chrysosporium, Cylindrocarpon, Fusarium, Paecilomyces, Penicillium, Trichoderma, and Verticillium or are representatives of the Phycomycetes or Sphaeropsidales.

Sixty-five of the species isolated have not been previously reported from Manitoba soil. Eleven previously undescribed species, including five placed within the genus Cylindrocarpon, and eight variants of known species, were among the fungi isolated.

Soil depth, culture media, and incubation temperature influenced the number and species of fungi recovered. The propagule number for beach ridge soil was greatest in the 10-20 cm profile, followed by the 20-30 cm and the 0-10 cm profiles. The most frequently occurring species were recovered throughout the 0-30 cm profile. Seventy-seven percent of all beach ridge fungi were isolated from the 10-20 cm profile; 72% and 62% of all fungi were isolated from the 0-10 cm and 20-30 cm profiles respectively. This atypical distribution pattern was thought to be a result of differences in organic content, moisture, and temperature within the undeveloped 0-30 cm beach ridge soil profile.

OAES culture medium recovered the largest number of propagules from

both beach ridge and marsh soils. The greatest diversity of species also resulted from the use of OAES medium. This was attributed to its effect on the nutrition and growth of fungi; discrete and slower growing mycelium on OAES allowed for more complete isolation of fungi compared to other culture media.

The overall effect of temperature on the number of propagules and diversity of fungi isolated was not consistent for beach ridge and marsh soils. The largest number of propagules from beach ridge soil was recovered on all media at lower incubation temperatures (10° C and 15° C). No such effect was observed for marsh soil. Species diversity was greatest at high incubation temperatures (20° C and 25° C) for beach ridge soil, but was greatest at a lower incubation temperature (15° C) for marsh soil where all but the lowest temperature produced similar results. The lowest incubation temperature (10° C) recovered the smallest complement of species from both soils.

Both incubation temperature and culture media were observed to affect the recovery of specific fungi from both soils. While the most frequently occurring fungi were recovered on all culture media at all incubation temperatures, some species were restricted in occurrence by culture media or incubation temperature. Six species appeared to be restricted by low incubation temperatures (10° C or 15° C) and four species by higher temperatures (20° C or 25° C), but they were not restricted by media. Ten species were restricted in appearance by culture media, but not incubation temperatures.

Variations exist in the composition and frequency of species from beach ridge and marsh soils, compared to similar soil types. While other dune-type soils contain the same dominant genera as beach ridge

soil, major differences exist in the composition and frequency of species within the genera Trichoderma, Fusarium and Penicillium.

Eight of the 12 most frequent marsh soil species are uncommon to other highly organic near-neutral soils. Most of the dominant marsh soil fungi are known cellulose decomposers. Two groups of fungi commonly present in organic soils, Gliocladium spp. and sterile mycelial forms, were absent in marsh soil. It is possible that a greater disruption of marsh soil before preparation of dilution plates is required for the isolation of sterile mycelial forms.

ACKNOWLEDGEMENTS

I would like to express my gratitude to those who assisted me during this study.

To Dr. James Reid, my thesis supervisor, thank you for your almost infinite patience, encouragement, constructive criticism, and friendship over the past ten years.

To my committee, Dr. Tom Booth, Dr. John Mills and Dr. David Punter, my appreciation for their review and critique of this thesis.

I would also like to thank my friends and fellow students in the Botany Department, who have provided a wealth of support and encouragement to me over the past ten years.

To my parents and mother-in-law and father-in-law, thank you for your love and help always, but especially when it was needed most.

Assistance for this study from an N.S.E.R.C. operating grant #A3683 held by Dr. J. Reid, and an N.S.E.R.C. scholarship granted to me in 1971, are gratefully acknowledged.

I would like to thank my wife Gloria and children Jordan and Melissa most of all for enduring years of thesis excuses; especially my wife, without whose effort this thesis would not have been completed and who served as bread winner, typist, proof reader, field assistant and moral supporter.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF PLATES

LIST OF PLATES (continued)

LIST OF PLATES (continued)

LIST OF PLATES (continued)

LIST OF PLATES (continued)

LIST OF TABLES

LIST OF TABLES (continued)

INTRODUCTION

AND

LITERATURE REVIEW

I. Microfungi in Canadian Soils

The occurrence of fungi on all manner of substrates is well known. While the role of fungi in soil has received considerable attention, only limited research has been conducted on the ecology of fungi from Canadian soils with just sixteen papers published. Bisby et al (1933, 1935), Kendrick (1962), Reddy and Knowles (1965), Morrall and Vanterpool (1968), Vaartaja (1968), Bhatt (1970), Widden and Parkinson (1973), and Widden (1979), surveyed a variety of agricultural and undisturbed natural soils from the temperate regions of Canada. Ivarsen (1965) and Widden and Parkinson (1979) surveyed Arctic tundra soils; Bissett (1975) and Bissett and Parkinson (1979 a, 1979 b, 1979 c) examined Alberta alpine soils. Bissett and Parkinson (1980) also investigated a subalpine soil.

Only two of these studies (Bisby et al 1933, 1935) deal with microfungi from Manitoba soils. The present study was designed to expand our knowledge of microfungi in two unique and previously uninvestigated Manitoba soils. The site chosen for this research was the University of Manitoba Field Station, Delta Marsh, Manitoba. Located at the southern tip of Lake Manitoba, the Field Station serves as a research facility for a wide range of studies in marsh ecology. The marsh ecosystem, with its varied and productive communities, contains soils which are likely to contain unique and diverse fungal populations.

The soils selected were from two distinct and different habitats: (1) a sandy loam from the beach ridge separating the marsh from Lake Manitoba; and (2) an organic muck from the *Phragmites* habitat of the marsh. Although the mycoflora of soils from these types of communities has not been investigated in Canada, surveys of the microfungi of soils

of a similar type, i.e. neutral to alkaline organic or sandy soils, have been conducted in a variety of other countries. Organic soils surveyed include those from a British (England) fen (Stenton, 1953), an Iowa (U.S.A.) forest (Taber, 1951), a Wisconsin (U.S.A.) cattail marsh (Tews, 1970, 1971), a British (England) salt marsh (Turner and Pugh, 1961; Pugh, 1972; Pugh, 1963), and the Florida Everglades, U.S.A. (Wallace and Dickinson, 1978). Sandy soils are represented by British (England) coastal dunes (Brown, 1958; Pugh, 1963; Pugh et al, 1963), Lake Michigan (U.S.A.) sand dunes (Wohlrab et al, 1963; Wohlrab and Tuveson, 1965), and Wisconsin (U.S.A.) willow-cottonwood lowland soil (Gochenaur and Whittingham, 1967).

A variety of approaches has been used to examine the mycoflora of soils depending on the type of information desired, i.e. taxonomic survey, seasonal variation, decomposition of litter, isolation and identification of fungi from distinct soil horizons, etc.. A common approach is to isolate the soil fungi and determine the species composition and frequency at various soil depths. This study takes such a survey approach and includes additional information on the numbers of fungi, taxonomy of undescribed or unusual species, and new reports of fungi from Manitoba soils.

2. Isolation Technique

Over the past eighty years, successive methods have been developed to overcome problems related to accurate and representative isolation of fungi from soil. Such problems are directly related to the fact soil is a complex heterogenous environment containing a mixed population of fungi in a number of forms (either mycelial or reproductive propagules); these can be active or inactive and have a variety of roles and

nutritional requirements (Garrett, 1951). Garrett (1955) noted that isolation techniques are selective; each has its own limitations and biases. Since no one method can yield a reliable picture of the total fungal activity in soil (Watson, 1970), workers must design and interpret their research to reflect this fact. Accurate and comparative information can be obtained, but only within the limits of the survey parameters and method(s) employed (Parkinson et al, 1971).

In a preliminary survey, a major objective should be to isolate as many different and representative species as possible from the total spectrum of soil microfungi. Hopefully this should in turn produce representative "population" data.

This objective can be accomplished by two general approaches. The first employs several different isolation methods simultaneously, each with its own bias and limitations, and compares the results. This approach is most often used when specific information about the role or activity of soil fungi is desired (Warcup, 1957; Chesters and Thornton, 1956; Parkinson and Thomas, 1965). The time, labour and laboratory facilities required by this approach generally makes it impractical for survey studies, although it has been employed by a number of workers (Brown, 1958; Sewell, 1959 c; Chou and Stephen, 1968).

A more common approach uses the isolation method judged to have the least degree of bias regarding the survey parameters of isolating and enumerating soil fungi. The reliability of this approach can be increased by controlling variables which select against the isolation of certain fungi, and by reducing the inherent bias in the methodology wherever possible.

A modified soil wash technique (Watson, 1960), combined with soil dilution plating or soil plating of washed soil (Warcup, 1950), utilizing four different media at four different incubation temperatures, was adopted for this study. This approach was adopted because the method's bias will not likely detract from the results, therefore yielding reliable and comparable qualitative and quantitative data while still remaining manageable.

(a) Soil Wash Technique

The soil dilution plate method originally designed for the isolation and study of soil bacteria and modified for fungi (Waksman, 1927) was, until recently, the most common method employed in studying the nature and number of soil fungi (Parkinson et al, 1971). The defects and sources of error of this method were reviewed by Brierly et al (1927) and consequently it has been modified by subsequent workers in an effort to obtain the best possible results.

A major defect is the significant advantage given to abundantly sporing species. These species, which predominate on soil dilution plates, are usually overrepresented in population estimates (Warcup, 1950; Parkinson et al, 1971). This likely bears little resemblance to the mycelial density of a particular species in soil because differences often exist in conditions required for the development of spores and mycelium (Hawker, 1950). In contrast, Warcup (1955 a) demonstrated that the mycelial component on soil dilution plates represented a group of often slow-growing sterile species. These mycelial species are underrepresented on soil dilution plates because of their inability to compete with faster growing species, and the smaller number of propagules

relative to sporulating species (Warcup, 1955 b, 1957).

Warcup (1950) introduced the soil plate technique for the direct isolation of fungi from soil. A larger number of species was isolated by this technique than from soil dilution plates from the same soil. Warcup attributed this to the loss of mycelial species attached to soil particles during successive soil dilutions; a conclusion supported by Cohen (1950). An examination of the lack of representation among soil isolates of species originating from mycelial propagules was conducted by Warcup (1955 b, 1957). In an effort to separate the active mycelial component from dormant or inactive spores, he plated hyphae or washed soil particles containing hyphae, directly onto an enriched agar medium. While the direct isolation method removed a large group of mostly sterile species missed by soil dilution plates, or soil plates, it suffers from a practical disadvantage in that it fails to isolate heavily sporing species found on soil dilution plates or soil plates (Williams et al, 1965). This feature limits the usefulness of this technique in surveys of soil fungi.

A number of other methods for direct isolation or observation of soil fungi has also been developed, including direct inoculation (Waksman, 1916), buried slide (Rossi, 1928; Cholodny, 1930; Ziemiecka, 1935; Isakova, 1938), immersion tube (Chesters, 1940, 1948), agar film (Jones and Mollison, 1948), and soil sectioning (Burges and Nicholas, 1961). However, all have a particular bias or selectivity which makes them unsuitable for soil surveys using a single method for the isolation, identification and enumeration of fungi.

The development of washing techniques, first applied to roots and organic particles (Simmonds, 1930; Kurbis, 1937; Glynne, 1939; Chesters, 1948; Robertson, 1954; Harley and Waid, 1955) and, later to

soil (Watson, 1960), proved to be an effective means of separating the vegetative and reproductive phases of soil fungi prior to plating on enriched culture media. The distinction and separation of these forms has been stressed by many researchers as important to our understanding of soil ecology (Chesters, 1949; Garrett, 1955; Harley and Waid, 1955; Chesters and Thornton, 1956; Sewell, 1959 c).

The soil wash method uses serial washings to remove most of the spores from soil and permits separate dilution plating of spore-laden wash-water and washed soil. This has the effect of reducing competition, resulting in a more realistic and complete picture of soil fungi compared to other methods. Watson (1960) and others (Parkinson and Williams, 1961; Williams et al, 1965; Parkinson and Thomas, 1965) report that serial washing of soil yields more genera of fungi (especially those originating from mycelium), a larger number of rare fungi, and more soil-borne pathogens than the soil plate or soil dilution methods when applied to the same soil. These advantages make this method a good choice for studies of a survey type.

The modifications of Watson's soil wash method for this study include an increase in the quantity of soil washed; fewer washings but with longer washing and settling times; and the use of a round-bottomed rather than a flat-bottomed, washing flask. Washing of larger volumes of soil than those employed by Watson, has been demonstrated to produce a greater revelation of the fungal composition of soil (Lisina-Kulik and Moiseeva, 1971). The washing and settling times employed fall within the acceptable limits for spore removal and still yield good species diversity for plated washed soil (Watson, 1960; Lisina-Kulik and Moiseeva, 1971). It was observed in preliminary tests that superior

washing action was generated by use of round-bottomed, as opposed to flat-bottomed, flasks.

(b) Dilution Technique

The wash water from both the sandy-ridge soil and organic-muck was diluted and plated in the manner described by Watson (1970). However the washed soil received differential treatments. The organic-muck received the standard soil dilution plate treatment while soil plates (Warcup, 1950) were prepared from the washed sandy-ridge soil. It is recognized that highly mineral soils are best prepared as soil plates because of excessive particle settling during serial dilutions (Brown, 1958; Montégut, 1960; Wohlrab et al, 1963).

Replicate dilution plates were prepared from a number of dilution sets rather than a large number of replicates from a single dilution set. This technique was demonstrated to improve the accuracy of the dilution plate method (James and Sutherland, 1939). Use of the Menzies' (1951) "dipper" helped prevent settling of soil particles during serial dilution preparation and sample removal. Soil particle suspension was further aided by the use of a 1% carboxy methyl cellulose solution as a diluent.

The final dilution for all plate counts was chosen to produce an approximate average of 25 colonies per plate as suggested by Bisby et al (1933) and recommended as statistically valid by James and Sutherland (1939). This produces plates which are relatively easy to count and should reduce competition and antagonism created by the use of higher density plates (Garrett, 1951).

(c) Culture Media

One of the most significant problems for the mycologist studying soil mycoflora is the selective growth and development of fungi after plating on a nutrient medium. Martin (1950) pointed out that culture media must be altered to promote the growth of the greatest possible number and variety of soil fungi; the latter being relatively less numerous in soil than bacteria and actinomycetes. The specific nature of the alterations falls into two broad categories: the addition of inhibitory chemicals which suppress either the development of bacteria and actinomycetes or the growth rate of certain fungi; and the addition of materials, usually specific nutrients, which promote the growth of fungi.

Acidification of culture media was the earliest modification attempted to suppress the growth of bacteria in mixed cultures (Waksman, 1922; Jensen, 1931; Tyner, 1944). The resulting reduction in numbers of pathogenic fungi led to the investigation of other possible suppressant chemicals. Smith and Dawson (1944) introduced the use of rose bengal, a bacteriostatic agent which reduced fungal spread and prevented actinomycete growth in culture. Streptomycin and crystal violet were subsequently shown to be effective inhibitors of bacterial growth (Littman, 1947). Culture media containing these two agents, combined with oxgall, were bacteria free and capable of supporting a full range of discrete nonspreading colonies of saprophytic and pathogenic fungi (Littman, 1947). The colonies failed to spread because of the suppression of growth by oxgall. More recently, sodium propionate (Crook et al, 1959) and synthetic detergents (Steiner and Watson, 1965) have been used to reduce the spread of fast growing soil fungi. Martin (1950), in a review of inhibitors, recommended the use of peptone-dextrose agar

containing rose bengal and streptomycin for the bacteria-free isolation of large numbers and kinds of fungi from soil.

All culture media employed in this study incorporated oxgall to suppress the spread of fungal colonies. Crystal violet and sodium propionate were also added to two of the media. Streptomycin sulfate and chloramphenicol were used to inhibit the development and growth of bacteria and actinomycetes.

The choice of a culture medium for the isolation and growth of fungi from a mixed population such as that in soil can produce biased results unless carefully considered. It is accepted that any culture medium is selective since fungi have a variety of nutritional requirements (Martin, 1950). However, because of differential growth rates, not all fungi capable of growth on a particular medium are isolated (Smith and Dawson, 1944; Chesters and Thornton, 1956). Some genera are therefore recorded in greater numbers than their actual mycelial concentration warrants (Watson, 1960).

Sewell (1959 c) demonstrated that the isolation of particular species of soil fungi from soil plates was affected by their growth rates on the isolation medium. The isolation medium of modified Rossi-Cholodny buried slides and immersion tubes also influences the mycoflora isolated from soil (Chesters, 1948; Chesters and Thornton, 1956; Sewell, 1959 c). This phenomenon may, in part, be due to the production of growth-inhibiting metabolic byproducts by some strains of soil fungi on enriched media (Chesters, 1948; Nicot and Chevaugeon, 1949). The concentration and type of carbohydrate in the isolation medium is also known to have a strong selective effect (Chesters, 1948; Cohen, 1950; Garrett, 1951).

Despite these problems most studies use a single culture medium for the isolation of soil fungi. The most commonly employed medium is Czapek-Dox or Czapek-Dox with yeast extract, a "broad spectrum" medium. In selecting a culture medium Parkinson et al (1971) suggest three broad groups be considered: soil extract based media; media containing peptone or a similar nitrogen source; and synthetic media. Since it was desirable to reduce the selective effect of culture media, four culture media were selected. Three of these are in the categories suggested by Parkinson et al, i.e. soil extract agar, Litmans crystal violet agar (Litman, 1947), and Ohio Agricultural Experimental Station agar (Williams and Schmitthenner, 1958). The fourth medium is a common, much used medium, potato dextrose agar. Williams and Schmitthenner (1958) have demonstrated these media are effective in the isolation of a broad range of soil fungi.

(d) Incubation Temperature

The incubation temperature of isolation plates has received only rare consideration as an operative variable in the isolation of fungi from soil (Dickinson and Kent, 1972). The incubation temperature selected is usually at or around room temperature (20° C - 25° C) and is rarely related to environmental temperatures. Panasenko (1967) notes that most soil fungi are mesothermotolerant and have a developmental temperature range of 5° C to 35° C with an optimum of 20° C to 25° C. This suggests that studies using this 20° C to 25° C incubation range are within the temperature requirement for development of most soil fungi. However, it is recognized that not all soil fungi have the ability to grow at the same rate at the same temperature on the same medium (Dickinson and Kent, 1972).

Bisby et al (1935) demonstrated that fungi exhibit spatial distribution patterns based on soil temperatures. The failure of certain species of fungi from the same soil to develop consistently on plates incubated at different temperatures (15° C and 25° C) was attributed by Dickinson and Kent (1972) to decreased competitive abilities at higher temperatures. Since the isolation of fungi from soil involves a mixed, spatially distributed population, a greater diversity of species will likely be isolated when a range of temperatures is employed.

Since a range of temperature probably exists in the soils sampled the four incubation temperatures selected, 10° C, 15° C, 20° C, and 25° C, probably reflect environmental conditions more closely than single temperature studies. This temperature regime, in combination with the media selected, provides a range of growth conditions for the potential development of a wide spectrum of soil-borne fungi.

(e) Soil Sampling

Any attempt to elucidate the mycoflora of soil must be preceeded by the collection of a representative soil sample(s). A variety of sampling methods are available and the frequency of sampling, number of samples, and the nature and depth of the soil to be sampled are major considerations in choosing a convenient and accurate sampling method. A core borer was used to sample both Delta Marsh soils; a technique pioneered by Jensen (1912). Although no definitive information on the most suitable size for core borers is available, the one used herein fits the guidelines outlined by Parkinson et al (1971).

Soil is usually sampled based on soil profiles. However, since the soils selected at Delta Marsh do not have well developed or distinct

profiles, soil samples were collected from three arbitrary depths: 0-10 cm, 10-20 cm, and 20-30 cm. The problem of removing a representative soil sample from a large sample area has been investigated by Rose and Miller (1954). They noted that variations in plate counts of soil fungi were mainly due to variation between sample cores and less due to subsampling and plating methods. This was, in part, due to the heterogeneous nature of the soil environment.

A large number of bulked cores were collected in this study as recommended by Rose and Miller (1954). Further, Lisina-Kulik and Moiseeva (1971) experimentally determined that the plating of bulked samples showed a greater number of species, genera, and colonies of various groups of fungi than the plating of individual samples.

3. Population Estimates

As discussed in the previous section, the requirement of methods used in this study is to provide conditions for the isolation from soil of as many fungal colonies as possible coupled with maximum diversity. The method used will also involve a certain degree of compromise and can probably never isolate a complete spectrum of soil fungi from the soil population. Those fungi isolated, however, should be numberically representative, i.e. they should represent as closely as possible the number of fungal propagative units within the soil population.

It should be noted that the term "population number" has little meaning when referring to the sum total of fungi isolated from a soil sample. The population only truly exists while the soil remains un-

disturbed and the fungi, once isolated, are best thought of as distant "relatives" of the parent soil population.

The value of having numerical data is in its comparative function, and not as an ultimate standard. The term 'estimate' possibly best describes this data. Egdell et al (1960) appropriately point out that different workers using the same methods on the same soil cannot produce uniform data. What these numbers actually represent is difficult to assess since the source of the growth, or propagative unit, on the isolation plate is uncertain. It may be a spore, fragment of mycelium, or a mass of mycelium. Also, some species produce more growth units per unit of soil mycelium than do others (Watson, 1960).

The terms "propagative unit(s)" and "propagule" are used throughout this study instead of the term "population number(s)" in recognition of these problems. Watson (1960) used the term "growth unit".

The numbers of propagative units have been calculated using the maximum plate counts for all culture conditions (all media at all temperatures) for each soil profile (Appendix F). Parkinson et al (1971) have recommended this method for International Biological Programme soil ecology projects.

Even with use of maximum values, dilution plate counts produce underestimates of the total viable population of soil. Skinner et al (1952) and Warcup (1957) have shown that many propagative units are not released from soil during soil dilution preparations. Washing of soil, however, should improve this shortcoming. As well, many propagative units fail to grow under certain culture conditions (Warcup, 1955 b; Williams et al, 1965). Hawker and Linton (1971) and Parkinson (1970) present evidence that indirect isolation methods produce lower population values for soil than do direct counting methods.

In summary, the objective of the present study was to determine the occurrence, distribution and propagule numbers of microfungi in soils from two habitats in Delta Marsh, Manitoba. The approach taken was to isolate, count and identify microfungi from soil cores collected in beach ridge and marsh habitats. The techniques used allowed for the isolation and identification of a large number and wide range of microfungi. These include the collection of a large number of bulked soil cores from each habitat, followed by serial soil washing and dilution plating of wash water and washed soil on a variety of culture media incubated over a range of temperatures.

METHODS AND MATERIALS

1. Site Description

(a) Site Location

The Delta Marsh is located at the south end of Lake Manitoba (50^{o} 11' N latitude, 98^{o} 23' W longitude) and covers approximately 15,000 hectares (Figure 1). The marsh proper is separated from Lake Manitoba by a forested ridge. This sandy beach ridge rises from the beach, forms a large stable crest, and then slopes to the south into the marsh. A number of channels traverse the ridge connecting Lake Manitoba to the marsh and elevated water levels which periodically occur in Lake Manitoba may cause inundation of the marsh through these channels.

Two soil sampling sites were chosen for this study: Site A, on the forested ridge approximately 1400 meters west of Mallard Lodge, University Field Station, Delta, Manitoba; and Site B, located 800 meters west of Mallard Lodge and 350 meters south of the lakeshore (Figure 2). These two sites were chosen because they differed with respect to soil type, vegetation and moisture regime.

(b) Site A

The forested ridge, a modified Agassiz beach, is underlain by glauconitic sandstone, shale, limestone and gypsum of the Sundance Rock Formation (Jurassic Period). The soil at this site is a member of the Agassiz Association - soils which have developed on gravel and coarse sandy beach deposits of limestone and granitic origin (Ehrlich et al, 1957).

The weakly developed soil on the crest of the ridge is covered

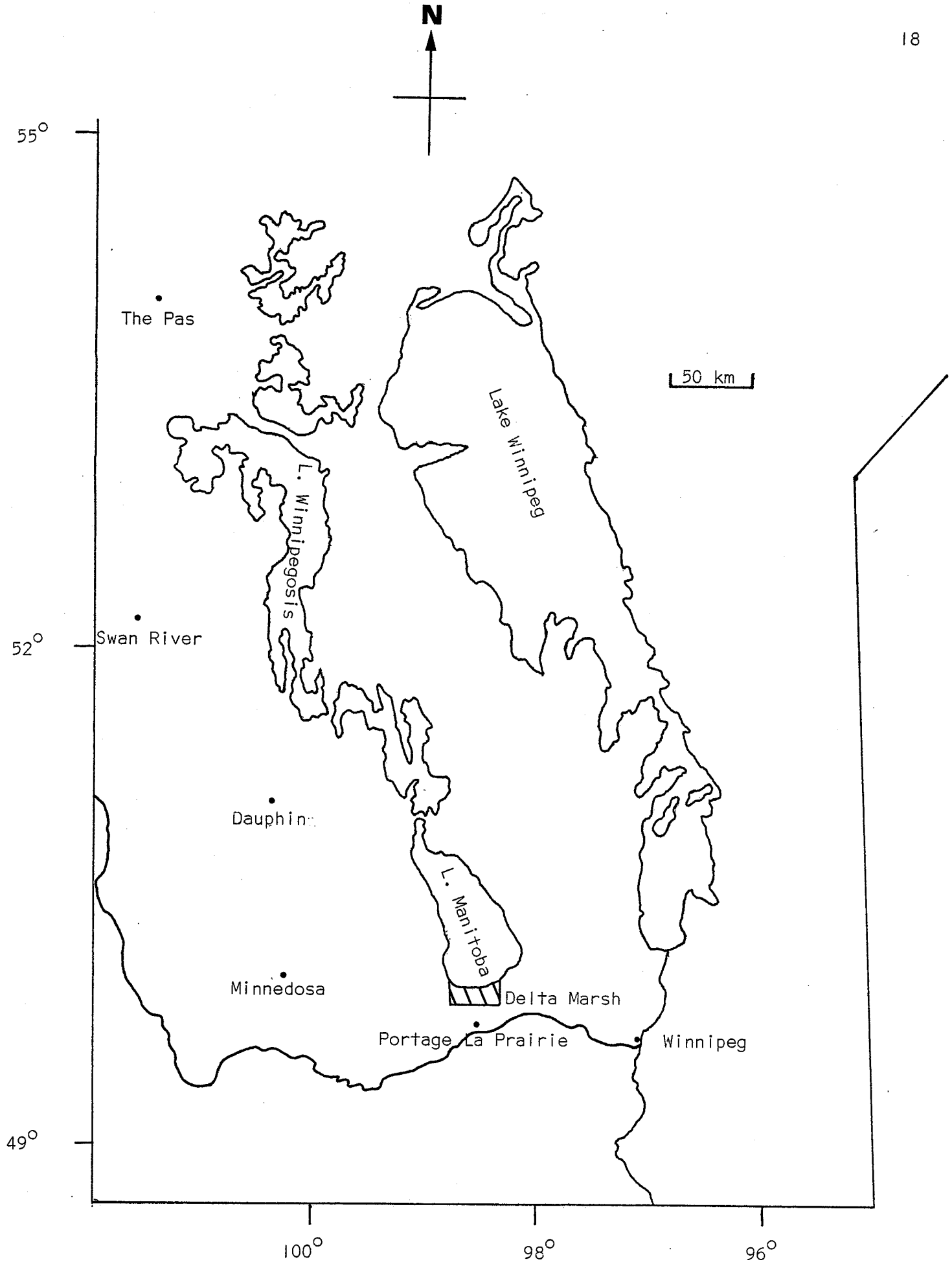


Figure 1. Map illustrating the location of Delta Marsh, Manitoba.

Figure 2. Aerial photograph of the location of Sampling Sites A and B.

by a thin layer of humus. Classified as a fine sandy loam (Ehrlich et al, 1957), it is interspersed with organic lenses. The soil on the raised beach has no humus layer, is mostly sand, but also contains a number of organic lenses.

Four sampling stations were selected at Site A; two of which were on the raised beach front on the north side of the ridge, and the other two on the crest of the ridge. The vegetation of these sampling stations varies in composition. The raised beach front, periodically inundated by water, is covered with a zone of Salix spp. which also contains a few individuals of Fraxinus pennsylvanica Marsh. Ground cover is completely lacking or very sparse. The well drained, drier crest of the ridge is vegetated by a stratified deciduous forest (Figure 3). The deciduous tree-layer consists of Acer negundo L., Fraxinus pennsylvanica Marsh, Ulmus americana L., and occasionally Populus spp. and Quercus macrocarpa Michx.. The shrub layer contains Cornus stolonifera Michx., Corylus americana Walt., Grossularia oxycanthoides (L.) Mill., Prunus virginiana L., Rubus idaeus L., Rosa blanda Ait., Sambucus pubens Michx., and Symphoricarpos occidentalis Hook (Walker, 1959).

In the open shaded areas of the ridge crest, which is dominated by large trees, the ground cover differs from those areas containing smaller trees and shrubs. A sparse cover of grass - Agropyron repens (L.) Beauv., Bromus inermis Leyss., Elymus hirsutiglumis Scribn., and Poa pratensis L.; and herbs - Sonchus arvensis L.; and Urtica dioica L. var. procera Wedd. dominate the open cover areas (Walker, 1959). Under denser cover, the diverse ground vegetation characteristically contains: Aralia nudicaulis L., Aster laevis L., Aster simplex Willd., Calystegia sepium L., Chamaenerion angustifolium (L.) Scop., Echinocystis lobata (Michx.) T. & G.,

Figure 3. Sampling Site A - The Beach Ridge.

Figure 4. Sampling Site B - The Marsh.

Humulus americanus Nutt., Mentha canadensis L., Oxybaphus nyctagineus (Michx.) Sweet, Polygonatum canaliculatum (Mühl) Pursh, Ribes americanum Mill., Sonchus uliginosus MB., and Urtica gracilis Ait. (Löve and Löve, 1954).

(c) Site B

Site B, located in the marsh, is underlain by the Sundance Rock Formation (Jurassic Period), and is covered by undifferentiated muck and peat (Ehrlich et al, 1957). The surface layers are waterlogged in the early spring (May) but dry down as the water table drops during the growing season. In 1971 the water table dropped from surface level in May to 83 cm below the surface in September (Phillips, 1976).

The vegetation at Site B is an almost pure stand of Phragmites communis Trin. with a sparse herb understory including Chenopodium rubrum L., Cirsium arvense (L.) Scop., Lycopus asper Greene, Mentha arvensis L., Stachys palustris L., Teucrium occidentale Gray, and Urtica dioica L. var procera Wedd. (Phillips, 1976) (Figure 4).

Four sampling stations were located at the corners of a 20 m x 25 m rectangular sampling plot at Site B.

2. Soil Sampling Procedures

(a) Site A

Each of the four sampling stations at Site A was 1 m^2 in area and consisted of four adjacent $\frac{1}{4}$ m^2 quadrats. The sampling sites and their divisions were delimited by a number of painted wooden pegs (Figure 5).

A square hard-board sampling template (Figure 6), which divided

Figure 5. A 1 m^2 Site A sampling station delimited by painted wooden pegs.

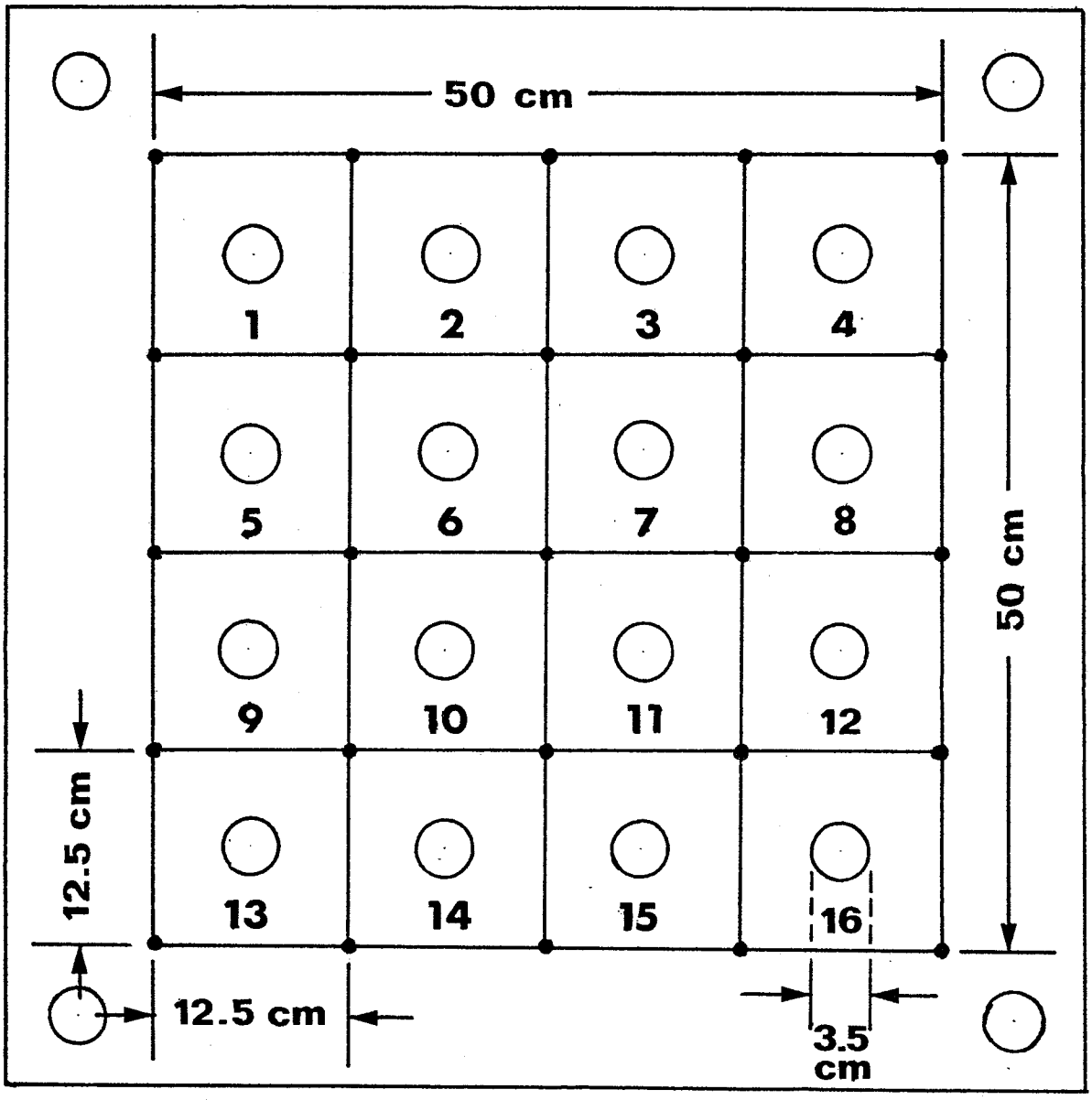


Figure 6. Diagram and dimensions of the $\frac{1}{4}$ m^2 hard-board sampling template.

each $\frac{1}{4}$ m^2 quadrat into sixteen 156.25 cm^2 sub-plots, was used to select the exact location for each soil sample in the following manner. The template was placed over the corner pegs of a quadrat (Figure 7 a), and four metal nails were pressed through the template at the corners of one of the 16 sub-plots, into the soil below (Figure 7 b). The template was then removed (Figure 7 c) and the soil samples taken within the 12.5 cm^2 sub-plot delimited by the four remaining nails (Figure 7 d).

On every sampling date three soil cores, totalling 30 cm in length and 2.8 cm in diameter, were removed from each of the four $\frac{1}{4}$ cm^2 quadrats at each of the four sampling stations. These soil cores were collected in three portions: a 0-10 cm fraction; a 10-20 cm fraction; and a 20-30 cm fraction. Cores from each of the three fractions were bulked as each station was sampled. This yielded a bulked total of 16 soil cores for each fraction (four cores at each of four stations).

The initial soil samples at site A were removed with a peat borer but subsequent samples were collected using a simple pipe core borer (Figure 8). This change was necessitated to prevent the mixing of upper and lower soil fractions which normally occurred when the peat borer was employed.

(b) Site B

At site B each sampling station was a circular plot with a circumference of 354 cm and an area of 1 m^2. Each station was divided into four $\frac{1}{4}$ m^2 quadrants (A, B, C and D); each $\frac{1}{4}$ m^2 quadrant was further subdivided into four 625 cm^2 sampling sections (Figures 9 and 10). The limits of both quadrants and sampling sectors were delimited by color-coded marker pegs (Figure 11).

A wedge-shaped sampling template was used to locate soil sampling

Figure 7 a. Sampling template in place over the pegs of a $\frac{1}{4}$ m^2 quadrat.

Figure 7 b. Sampling template with nails pressed through the corners of a 12,5 cm^2 sub-plot.

Figure 7 c. A 12.5 cm^2 sub-plot delimited by four nails.

Figure 7 d. Soil removal from a 12.5 cm^2 sub-plot using the pipe core borer.

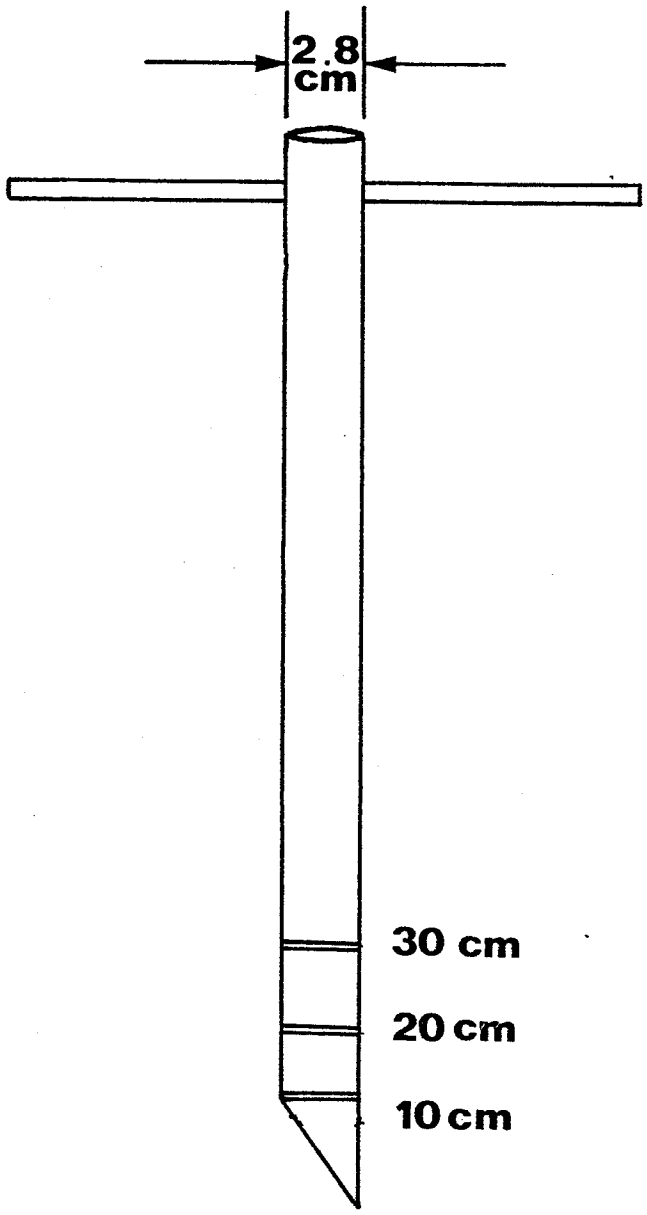


Figure 8. Diagram of pipe core borer.

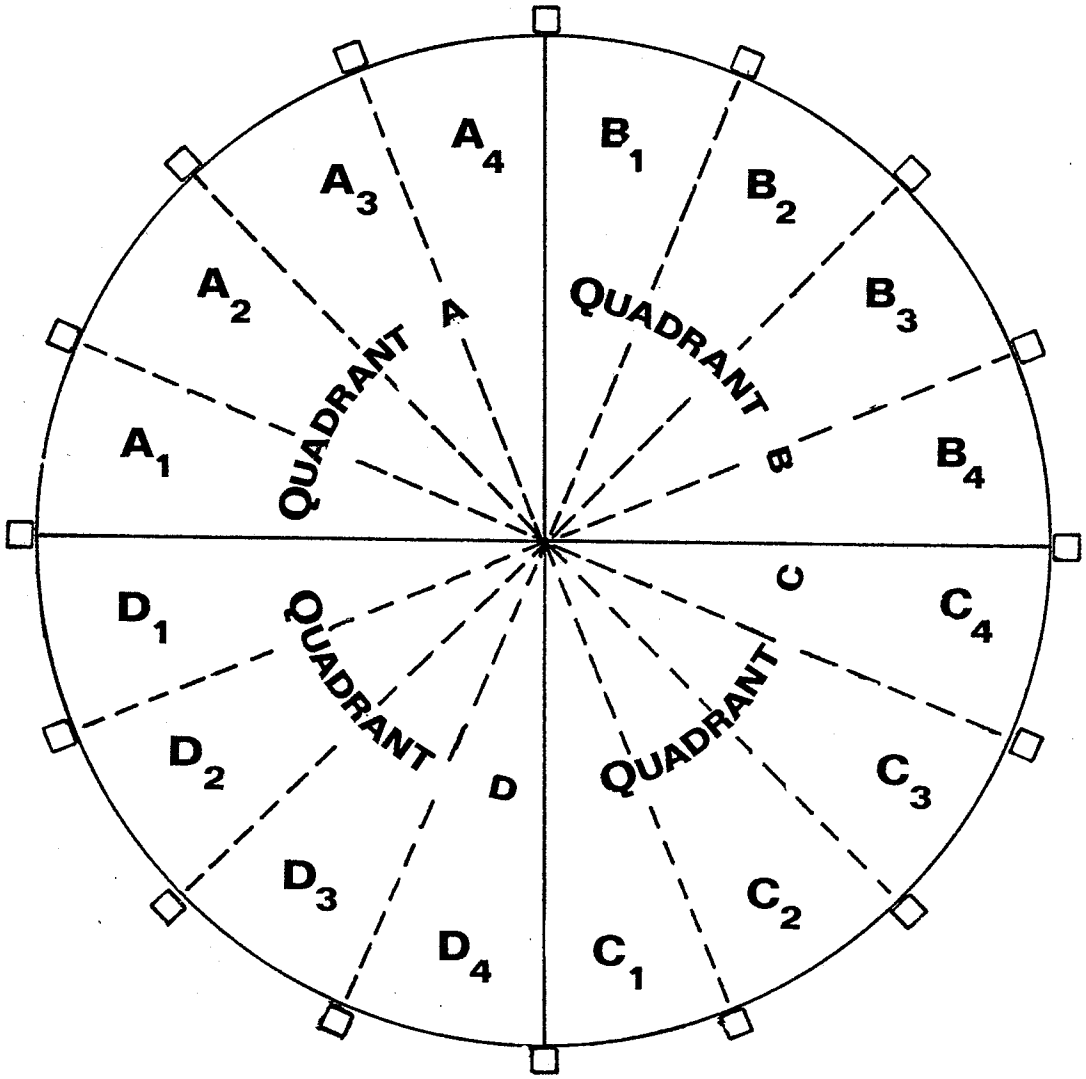


Figure 9. Diagram of 1 m^2 Site B sampling station showing the subdivision into $\frac{1}{4}$ m^2 quadrants and 1/16 m^2 sampling sectors.

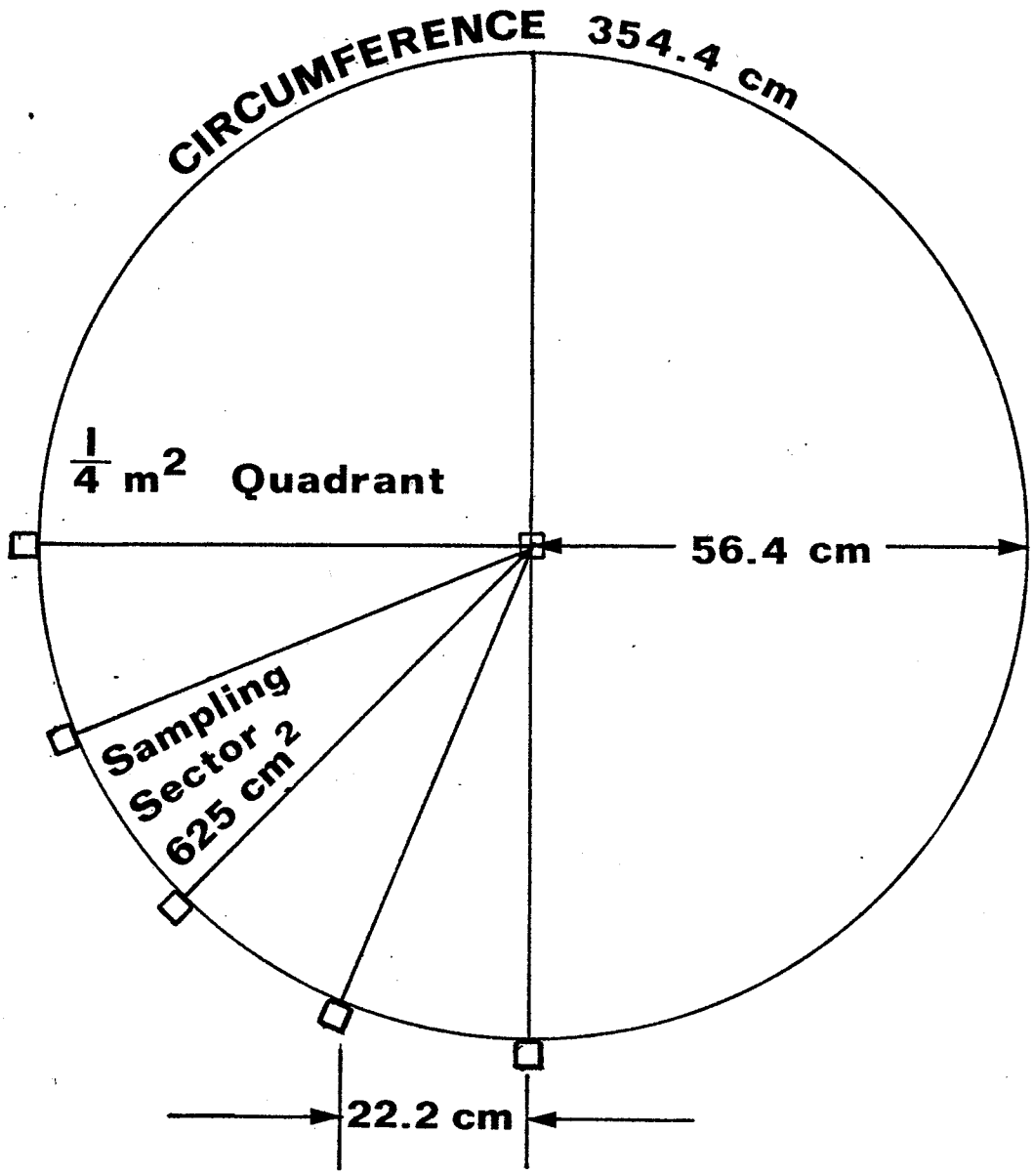


Figure 10. Diagram of 1 m^2 Site B sampling station showing the dimensions.

Figure 11. A 1 m^2 Site B sampling station delimited by color-coded marker pegs.

sites within each $\frac{1}{4}$ m^2 quadrant. The template, covering an area of 625 cm^2 was divided into four 156.25 cm^2 sampling compartments, each compartment being 1/16 of the total area of the $\frac{1}{4}$ m^2 quadrants (Figure 12). To locate the soil sampling site within a quadrant, the template was pushed between the Phragmites stems in one of four possible sampling sectors, and attached to the centre peg of the sampling site (Figure 13 a). Next, the core borer was placed in the appropriate sampling compartment of the template, and a soil core removed (Figure 13 b). Subsequent samples were collected by moving the sampling template to the next sector in the sampling sequence and removing a soil core from the appropriate sampling compartment (Figures 13 c, 13 d and 13 e).

Early in the growing season, when the soil was waterlogged, a single 30 cm x 2.8 cm core was removed in each $\frac{1}{4}$ m^2 quadrant. The 30 cm cores were then divided into three fractions; 0-10 cm, 10-20 cm, and 20-30 cm. As the soil dried down during the growing season, cores were removed in separate 10 cm portions. On each sampling date four 30 cm cores, one from each $\frac{1}{4}$ m^2 quadrant, were removed from each sampling station, either in a single 30 cm core or in 10 cm fractions. Each soil fraction was bulked as stations were sampled.

As with site A, initial samples (June 28, 1971) were removed with a peat borer, later samples were taken with a simple pipe core borer.

The soil sampling techniques of the two sites were designed to allow for the difference in vegetation. With the square hardboard template used on the ridge, low growing grass, herbs and shrubs could be pressed down during sampling without damage. This templete was unusable in the dense tall stands of Phragmites because its use would cause excessive vegetation damage. The wedge-shaped sampling template, however, could be pushed between the Phragmites stems with little or no damage,

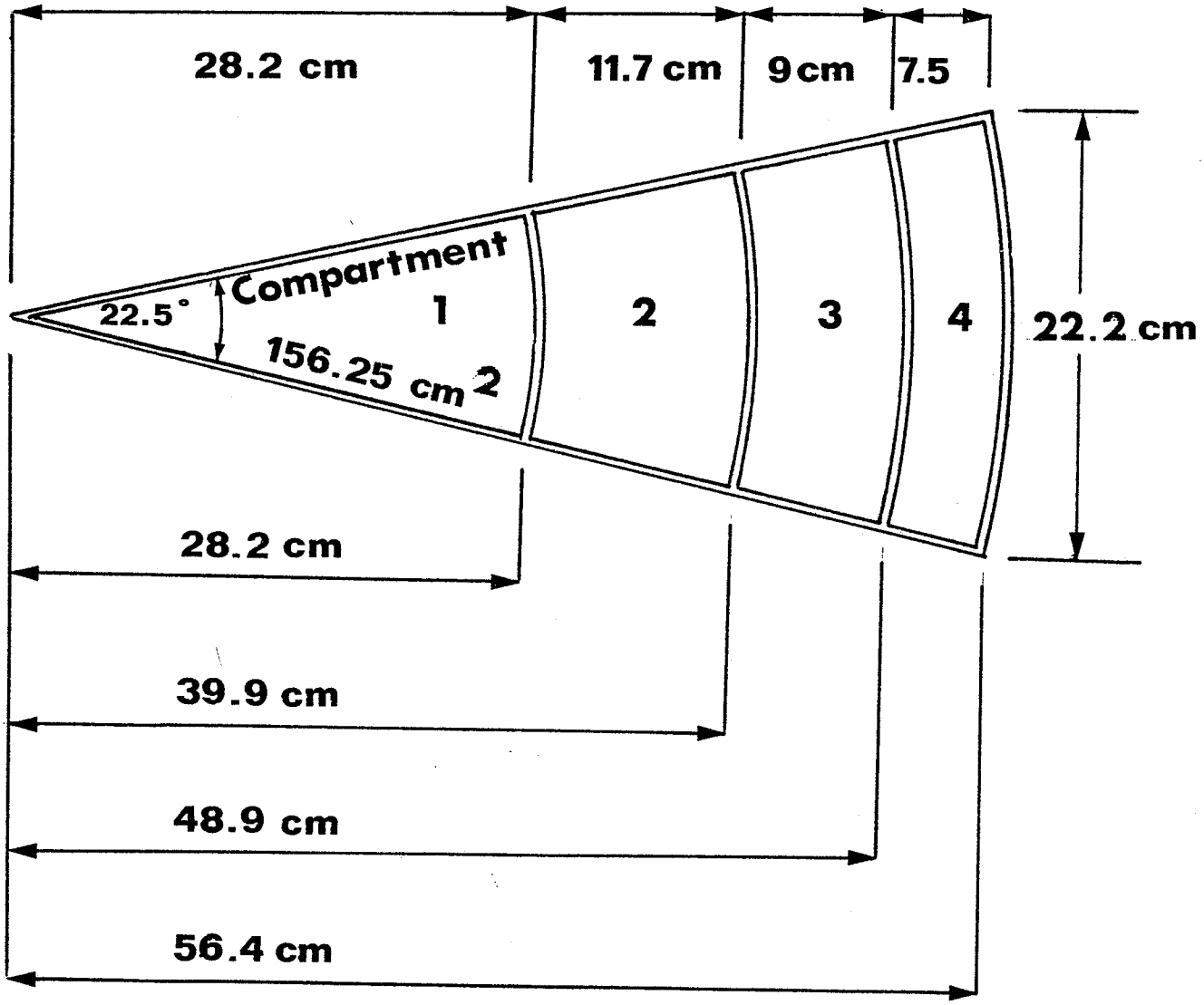


Figure 12. Diagram and dimensions of the 625 cm^2 Site B sampling template.

Figure 13 a. Sampling template in place in a sampling sector A, of quadrant A.

Figure 13 b. Core borer removing a soil sample from a compartment of the sampling template.

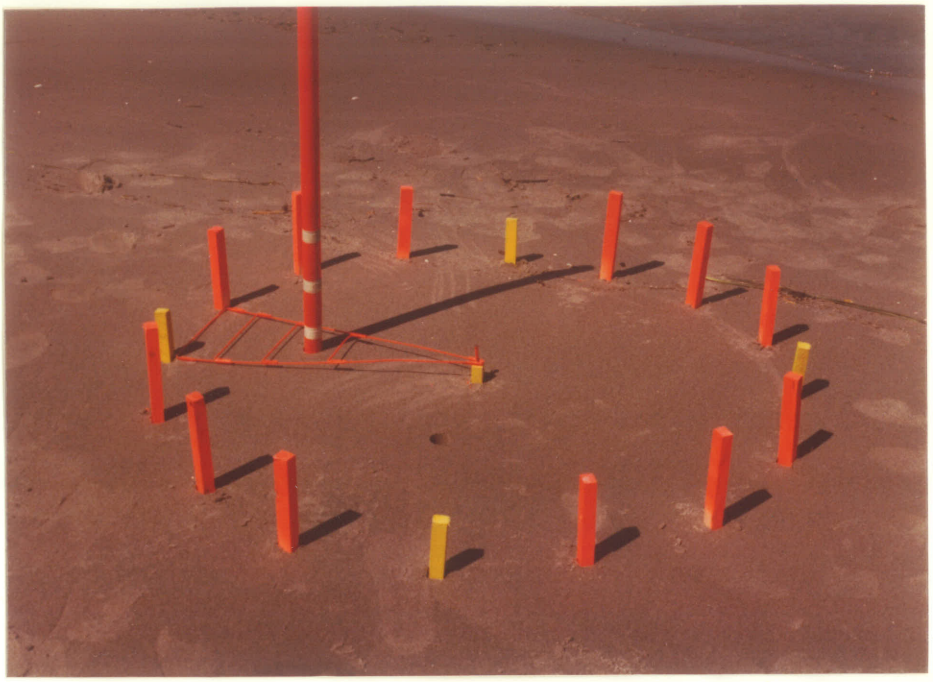


Figure 13 c. Core borer removing a soil sample from compartment 2, sampling sector B.

Figure 13 d. Core borer removing a soil sample from compartment 3, sampling sector C.

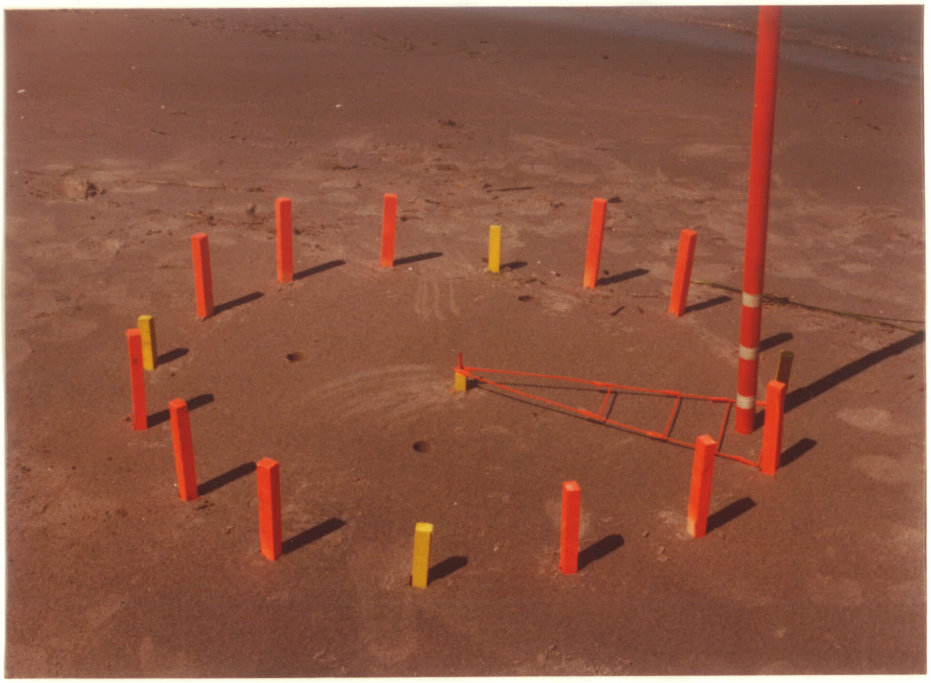


Figure 13 e. Core borer removing a soil sample from compartment 4, sampling sector D.

and still allow for convenient and accurate soil sampling.

(c) Sampling Schedules

The sampling schedule was designed for weekly sampling over a 16-week period for both sites A and B. This schedule proved to be unrealistic because of the large amount of time required to maintain the laboratory work. The original schedules for both sites are included in Appendix A. The sites were sampled four times and conform to week numbers 1, 2, 3 and 4 listed in the sampling schedule. The sites were sampled on the following dates: Site A - June 17, July 31, August 25, and September 25, 1971; Site B - June 28, July 29, August 27 and September 25, 1971. The June 17 sample was the only sample processed from site A. The June 28 and July 29 samples from site B were amalgamated and were the only samples processed from site B.

3. Laboratory Studies

(i) Soil Washing Technique (Figure 14)

Soil samples were stored at 4^{o} C as soon as possible after collection, but prior to processing, they were removed from storage, allowed to return to room temperature, then thoroughly mixed. An aliquot from each soil fraction (0-10 cm, 10-20 cm, and 20-30 cm) was weighed and placed in a sterile 500 ml round-bottomed flask. Thirty grams wet weight of soil was weighed for each site A soil fraction; these were diluted with 270 ml of sterile distilled water to produce a concentration of 10^{-1} $\frac{\text{g wet weight of soil}}{\text{ml}}$. Soil fractions from site B were weighed on a 30 g dry weight equivalent basis after the moisture content of each soil fraction had been determined. Sterile distilled water was added to these soil fractions to produce a final dilution of 10^{-1} $\frac{\text{g dry weight of soil}}{\text{ml}}$. All flasks were stoppered and shaken on a Burrell wrist action shaker at

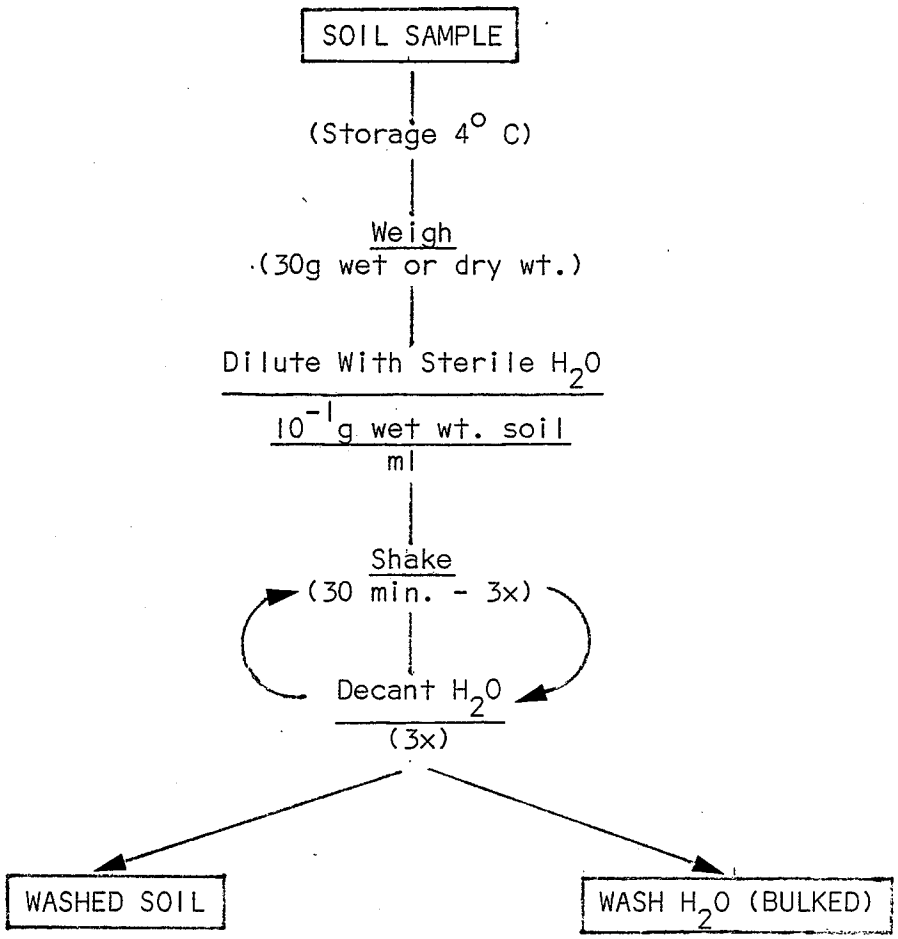


Figure 14. Flow Chart of Soil Washing Technique.

for 30 minutes. The washed soil was allowed to settle for 15 minutes, the wash water then decanted into a sterile 1000 ml Erlenmeyer flask which was stoppered with a sterile cotton plug. An equivalent amount of sterile distilled water replaced the wash water and the soil was rewashed using the same procedure. Each soil fraction received three washings; the wash water for each soil fraction was bulked during this procedure.

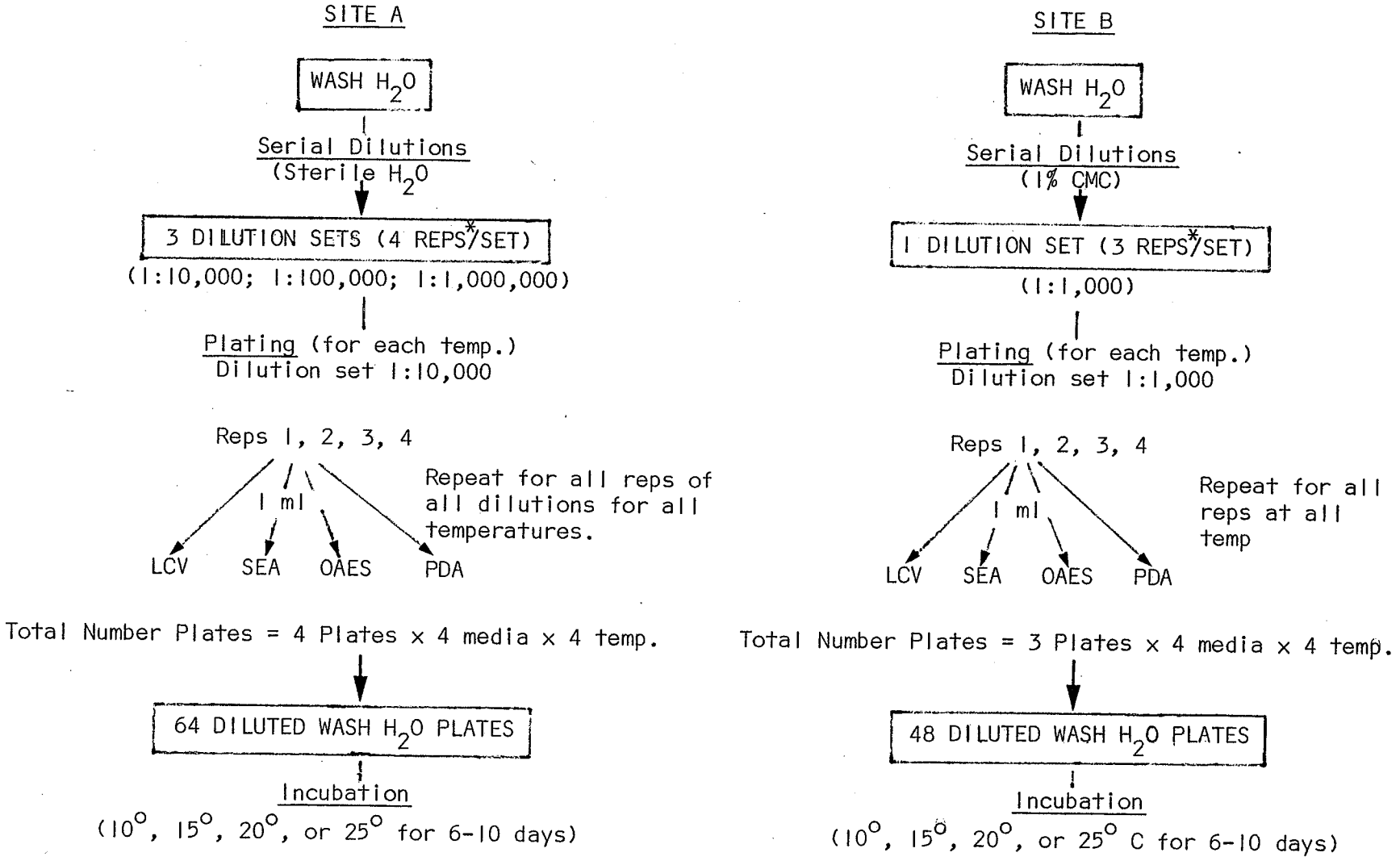
(ii) Dilution Plating (Figure 15)

Serial dilutions of the wash water from each soil fraction were prepared. Using a 10 ml sterile pipette, 10 ml of wash water was serially diluted by transferring to a series of 100 ml milk dilution bottles containing 90 ml of sterile distilled water. For site B soil fractions, sterile 1% aqueous carboxy methyl cellulose (CMC) was used as a diluent to prevent the settling of suspended soil particles.

Three sets of dilutions (1:10,000; 1:100,000; 1:1,000,000) were prepared for each soil fraction wash from site A and each dilution set contained four 100 ml replicate dilutions. One dilution set (1:1,000) was prepared for the site B soil fraction wash and this set contained three 100 ml replicate dilutions.

Diluted wash water was mixed with four different culture media: potato-dextrose agar (PDA); Ohio Agricultural Experimental Station agar (OAES); soil extract agar (SEA); and Litman's crystal violet agar (LCV) (Appendix B). All media contained streptomycin sulfate and chloramphenicol to inhibit the growth of soil bacteria, and the growth inhibitor oxgall to prevent fungal colony spread.

To prepare a dilution plate a one ml sterile dipper was used to transfer one ml aliquots of wash water to sterile plastic petri plates. Approximately 20 ml of culture medium, at 45^{o} C, was immediately added to



* REPS = Replicates

Figure 15. Flow Chart of Dilution Plating Method.

each plate and mixed with the sample by swirling the dish in a circular motion.

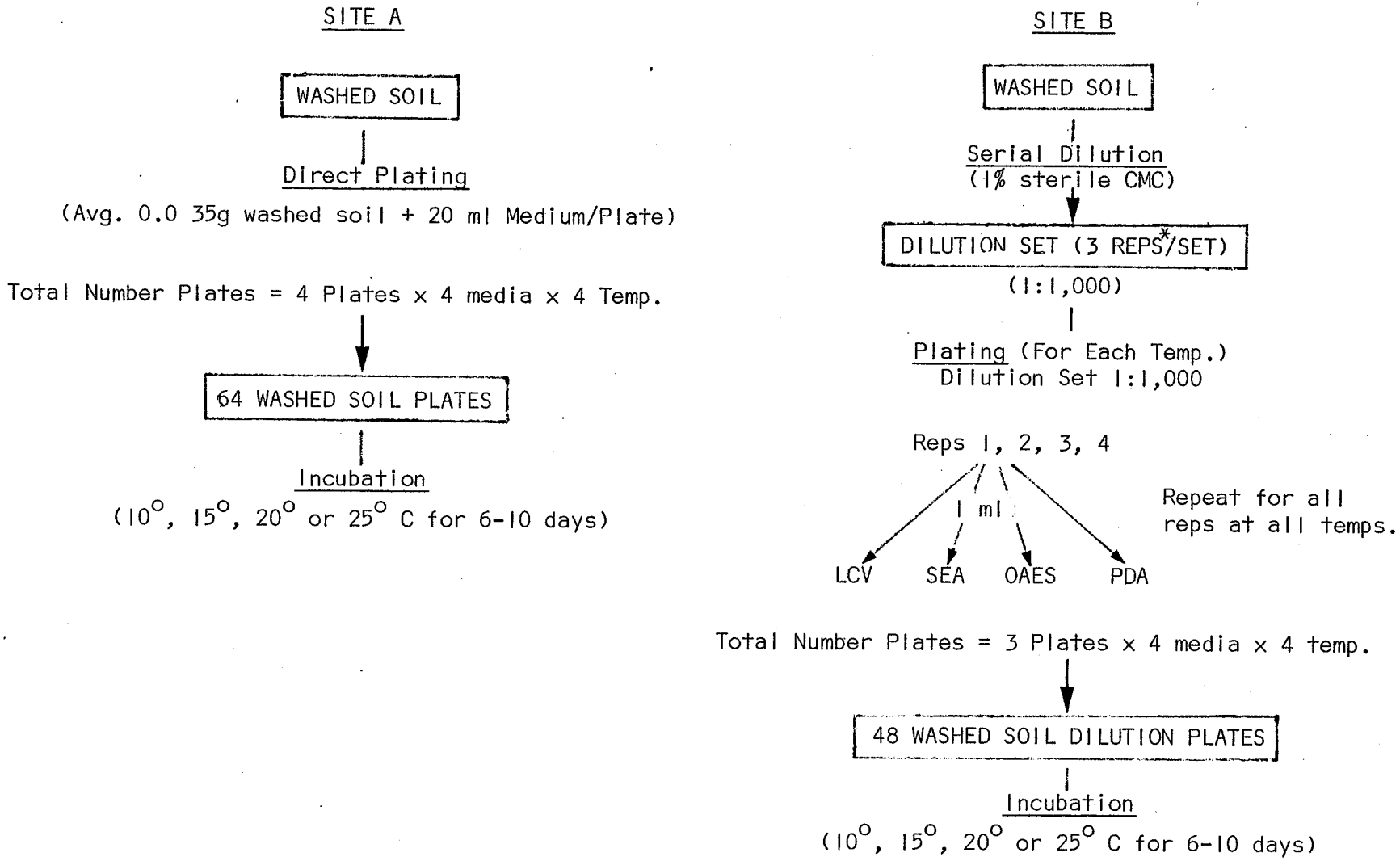
Samples from each soil fraction dilution were plated separately on the four different culture media and incubated at four different temperatures; 10° C, 15° C, 20° C, and 25° C. In the case of soil fractions from site A, four replicates of each combination of culture medium and temperature were prepared; one from each of the four replicates of the dilution set. Only three replicates were prepared for each culture medium-temperature combination for each site B soil fraction, one from each of the three replicates of the wash dilution set. All plates were incubated in the dark at the appropriate temperature for between six and ten days.

(iii) Washed Soil Plating (Figure 16)

Washed soil from both sites was cultured under identical conditions to the diluted soil washes, i.e. on the four different culture media at four different temperatures.

The washed soil fractions from site A were plated undiluted with molten culture media. A small aliquot (0.035 grams) of washed soil was aseptically transferred with a spatula to a sterile petri plate, and approximately 20 ml of molten culture medium at 45° C was added to the petri plate. The two were then mixed by swirling the plate in a circular pattern. Four replicates from each soil fraction were transferred to each culture medium for each incubation temperature. Aliquots of washed soil equivalent to those transferred to petri plates were removed for wet and dry weight determinations.

The washed soil fractions from site B were diluted before they were plated with culture medium. A one ml sample of washed soil was



* REPS = Replicates

Figure 16. Flow Chart of Washed Soil Plating Method.

transferred with a sterile one ml dipper to 99 ml of a sterile 1% aqueous solution of CMC in a 100 ml milk dilution bottle. This was further diluted by serially transferring 10 ml aliquots to a series of 100 ml milk dilution bottles containing 90 ml of sterile 1% CMC until a final dilution of 10^{-3} $\frac{\text{g wet weight of washed soil}}{\text{ml}}$ was reached. A set of soil dilutions containing three replicate dilutions was made.

The soil dilution plates for each site B soil fraction were prepared in triplicate for each culture medium-temperature combination; one replicate from each of the three bottles in the soil dilution set.

All plates were incubated under conditions identical to the soil wash dilution plates.

(iv) Culture and Storage of Isolated Fungi (Figure 17)

When sufficient growth had occurred, the incubated culture plates for each soil fraction were removed from the incubator, and the fungi isolated. All possible fungal colonies were isolated by cutting out a section of each colony with a sterile needle and transferring it to a petri plate containing the appropriate isolation culture medium. The four culture media (PDA, OAES, SEA and LCV) were used but lacked streptomycin sulfate, chloramphenicol and oxgall. Sodium propionate and crystal violet were also eliminated from the OAES and LCV respectively.

Fungi from site A soil fractions were routinely isolated from the 1:10,000 soil wash dilution plates; however, in some cases the 1:100,000 and 1:1,000,000 dilution plates were used because of overgrowth.

Each isolated colony was numbered according to site, soil fraction, incubation temperature, and wash fraction using a coding system designed for this study (Appendix C).

The new transfers were then returned to a dark incubator at the

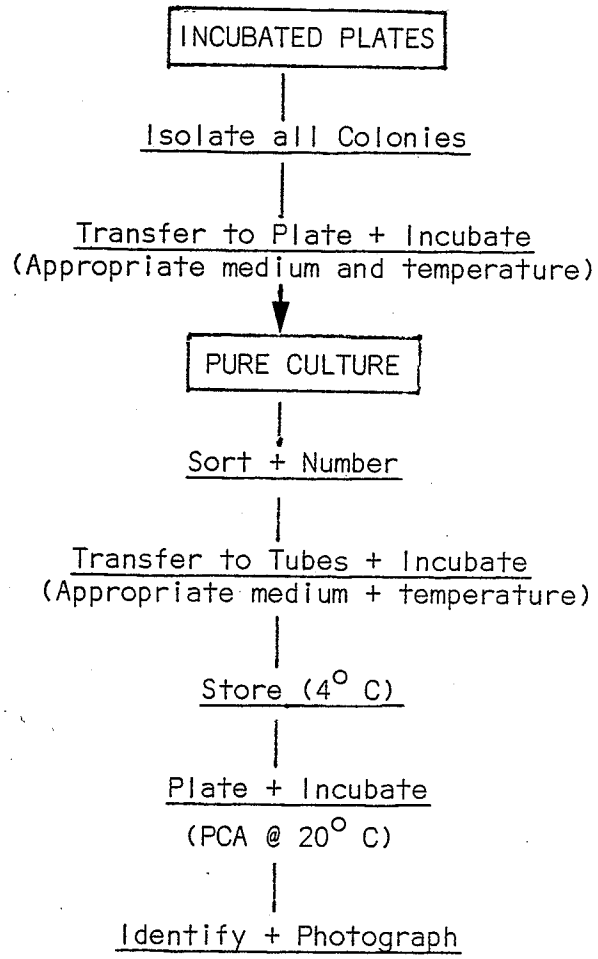


Figure 17. Flow Chart of Culture, Storage and Identification of Isolated Fungi.

same temperature at which they were originally isolated. When sufficient growth had occurred the culture plates for each soil fraction were visually sorted and cultures which appeared to be the same were grouped and recorded under a single culture number. Where doubt existed, the cultures were checked under an Olympus binocular stereoscopic microscope. The culture plates were stored at 4° C in sealed polyethylene bags until they could be transferred to culture tubes.

Duplicate aseptic transfers to a gar slants were made for each culture retained. The tubes were labelled with the culture number and returned to the dark incubators. When the surface of the agar slant was covered with growth, the tubes were removed and prepared for storage. The cap of one tube of each pair was sealed with masking tape, the remaining culture was covered with sterile mineral oil. All culture tubes were stored upright in racks at 4° C until they were regrown for identification.

(v) Identification and Photomicrography of Fungi (Figure 17)

Fungal cultures were regrown for identification from culture tubes stored at 4° C onto petri plates containing half strength potato carrot agar (PCA) (Appendix B). All plates were incubated at 29° C in a Controlled Environment growth cabinet programmed to a twelve-hour light - twelve-hour dark regime. Light was provided by cool white flourescent tubes and/or near ultra-violet tubes.

Regrown cultures were first examined using an Olympus binocular stereoscopic microscope, then a small sample of each culture including characteristic fruiting structures was mounted in lactophenol, or lactophenol cotton blue, or lactophenol fast green, on standard glass microscope slide with a No. 1 glass coverslip. Slides were examined under phase contrast optics on a Zeiss Photo-microscope II, and identified

using standard taxonomic keys (Ainsworth, 1961; Ames, 1961; Barnett and Hunter, 1972; Barron, 1968; Booth, 1966; Booth, 1971; Brown and Smith, 1957; Carmichael, 1962; Clements and Shear, 1931; de Hoog, 1972; Domsch and Gams, 1970; Dorenbosch, 1970; Ellis, 1971; Gams, 1971; Gams and Gerlagh, 1968; Gilman, 1959; Malloch and Cain, 1971; Morton and Smith, 1963; Raper and Thom, 1968; Rifai, 1969; Samson, 1974; Schol-Schwarz, 1970; von Arx, 1970). Of the major groups of fungi encountered (Phycomycetes, Ascomycetes and Fungi Imperfecti) sually only the Ascomycetes and Fungi Imperfecti were identified to species.

The less common or unusual species were photographed with phase contrast optics (Ziess Photomicroscope II) and/or interference contrast optics (Wild Ortholux II) using Kodak Panatomic-X film; routine film development procedures employing Kodak D-76 developer followed (Appendix D). Enlarged prints on single weight Kodak Polycontrast-F photographic paper were produced using Kodak D-72 developer and standard procedures (Appendix D); these prints were then incorporated into a set of composite plates. The plates were rephotographed on a 4" x 5" film format and reprinted onto 8½" x 11" single weight Kodak Polycontrast-F photographic paper.

RESULTS: TAXONOMY

1. Acremonium crotocinigenum (Schol-Schwarz) W. Gams, 1971, Cephalosporium-artige Schimmelpilze:112.

(Plate I, Figures a - c)

As reported by Gams (1971), the conidia of this species are very variable. However, the Delta isolates produce spores well within the range given by Gams, although I never encountered the two-celled spores which he records, nor did I note chlamydospores.

This fungus was isolated from beach-ridge soil, and has not been previously reported in Manitoba.

Cultures - UM 54 (CBS)

2. Acremonium furcatum (F. & R. Moreau) ex W. Gams, 1970 (1969) Nova Hedwigia 18:3.

(Plate I, Figures d - h)

The Delta isolates of this species have conidia which are slightly longer and wider than the measurements reported by Gams (1971), and occasionally the conidia appear dumb-bell shaped rather than cylindric. However, the differences are minor and do not warrant separation of the Delta isolates into a separate taxon.

This fungus was isolated from marsh soil, and has not been previously reported in Manitoba.

Cultures - UM 182 (CBS), UM 183 (CBS) and UM 187 (CBS)

3. Acremonium persicinum (Nicot) W. Gams, 1971, Cephalosporium-artige Schimmelpilze:75.

(Plate II, Figures a and b)

The Delta isolates assigned to this species agree closely with

the description given by Gams (1971).

This fungus was isolated from marsh soil, and has not been previously reported in Manitoba.

Cultures - UM 103 (CBS), UM 105 (CBS) and UM 189 (CBS)

4. Acremonium sclerotigenum (F. & R. Moreau ex Valenta) W. Gams, 1971, Cephalosporium-artige Schimmelpilze:45.

(Plate II, Figures c and d)

This species is normally characterized by the presence of hard, spherical, smooth, hyaline sclerotia, 15-50 (90) u in diameter. However, the Delta isolate never produced sclerotia, even in prolonged culture, but in all other respects conformed to the description given for this species by Gams (1971).

This fungus was isolated from beach-ridge soil, and has not been previously reported in Manitoba.

Cultures - UM 186 (CBS)

5. Acremonium strictum W. Gams, 1971, Cephalosporium-artige Schimmelpilze: 42-43.

(Plate II, Figures e and f)

Cultures isolated from both marsh and beach-ridge soil are quite uniform in their characteristics, and all conform well with Gams (1971) description of this organism.

This fungus has not been previously reported in Manitoba.

Cultures - UM 102 (CBS), UM 104 (CBS) and UM 188 (CBS)

6. Alternaria alternata (Fr.) Keissler, 1912, Beih. Bot. Zbl. 29:434.

Cultures isolated from both marsh and beach-ridge soil match the published descriptions of this common fungus. It has been previously reported from soil in Manitoba by Sutton (1973).

Cultures - UM 63 (CMI)

7. Arthrinium phaeospermum (Corda) M. B. Ellis, 1965, Mycol. Pap. 103: 8-10.

(Plate II, Figures g - i)

Cultures isolated from marsh soil match the published descriptions of this fungus (Ellis 1965 and 1971). It has previously been reported in Manitoba on Phragmites communis Traen. and also from soil by Sutton (1973).

Cultures - UM 27 (CMI)

8. Arthroderma curreyi Berk., 1860, Micr. Journ. ii:240.

(Plate III, Figures a - c)

Cultures isolated from both marsh and beach-ridge soil match the published descriptions of the conidial state of this fungus, which has not been previously reported in Manitoba.

Cultures - UM 75 (ALTA)

9. Ascodesmis sphaerospora Obrist, 1961, Can. J. Bot. 39:948-950.

(Plate III, Figures d - i)

Cultures isolated from beach-ridge soil match the published description of this fungus (Obrist, 1961). It has not been previously reported in Manitoba.

Cultures - UM 60 (CBS)

10. **Beauveria bassiana** (Bals.) Vuill., 1912, Bull. Soc. botan. France 59: 34-40.

(Plate IV, Figures a - d)

MacLeod (1954) in his critical analysis of the characteristics adopted by earlier investigators to differentiate between presumed species of Beauveria, suggested they were not sufficiently distinct or prominent to warrant establishing seperate species. If one did not accept MacLeod's treatment of this genus, then our cultures would have been referable to Beauveria globulifera (Speg.) Picard (a variable species) strains of which produce a red-purple pigment in culture - a feature which is common with our isolates.

This culture was isolated from beach-ridge soil, and has not been previously reported in Manitoba.

Cultures - UM 112 (SSM), UM 113 (SSM), UM 114 (SSM), UM 115 (SSM) and UM 116 (SSM)

11. **Botryotrichum piluliferum** Sacc. & Marchal, in Marchal, 1885, Bull. Soc. r. Bot. Berg. 24:66.

(Plate IV, Figures e - g; Plate V, Figures a and b)

Cultures of this fungus isolated from the marsh soil lack the setae which are normally characteristic of this species. However, in all other characters, e.g. production of both blastic and phialidic conidia, nature of the conidiophores, etc., the cultures conform to published descriptions of B. piluliferum.

This fungus has been previously reported from Manitoba soils by Bisby et al. (1938).

12. **Botrytis cinerea** Pers. ex Fr., 1832, Syst. mycol. 3:393.

(Plate V, Figures c - g)

This fungus, which appears to be ubiquitous on all types of decaying vegetable material, was isolated from the marsh soil. It has been previously reported from Manitoba by Bisby et al. (1938).

Cultures - UM 25 (CMI) and UM 44 (CMI)

13. **Chaetomium funicolum** Cooke, 1873, Grevillea 1:176.

(Plate VI, Figures a - d)

This fungus, which is commonly isolated from dung of various animals and from decaying plant materials, was isolated from marsh soil during this study.

Bisby et al. (1938) have previously reported the presence of this fungus in Manitoba.

Culture - UM 22 (CMI)

14. **Chrysosporium merdarium** (Link ex Fr.) Carmichael var. roseum W. Gams, 1969, Nova Hedwigia 18:6-7.

(Plate VII, Figures a - c)

This rather rare variety was separated on the basis of the deep rose-colored, wooly to mealy colonies which bear more or less spherical aleuriospores that are slightly flattened at their point of attachment.

This fungus was isolated from marsh soil, and has not been previously reported from Manitoba.

Culture - UM 193 (CBS)

15. Chrysosporium pannorum (Link) Hughes, 1958, Can. J. Bot. 36:749.

(Plate VII, Figures d - f)

Isolates obtained from marsh and beach-ridge soils agree with the published descriptions of this species. It has been previously reported as occurring in Manitoba soils by Bisby et al. (1938), under the name Geomyces vulgaris Traaen.

Cultures - UM 70 (ALTA), UM 71 (ALTA), UM 72 (ALTA), UM 73 (ALTA), and UM 122 (DAOM)

16. Cylindrocarpon tax. sp. 1

(Plate VIII, Figures a - f; Plate IX, Figure a)

Isolated from beach-ridge soil this fungus belongs in the genus Cylindrocarpon but represents a new species.

Single conidia incubated on PDA at 22 - 25° C produce colonies 25 - 33 mm in diameter after ten days. From above, aerial mycelium white, floccose becoming felted, off-white near the colony margin; in reverse central area light sienna diffusing into a wide band of pale luteous bounded by a creamy white margin. Conidia are formed from simple lateral phialides or from phialides borne on lateral dichotomously branching conidiophores; occasionally producing sporodochia-like masses (Plate VIII, Figures b and c). Phialides straight-sided, tapering at tip and with a prominent apical collarette; 13 - 30 x 2 - 2.8 µ (Plate VIII, Figure d). Conidia straight or slightly curved, cylindric to slightly obclavate with rounded distal ends and tapered, truncated distal ends; 0 - 1 septate; 16 - 25 x 3 - 5 µ. True chlamydospores are not produced but instead after 2 - 3 weeks many hyphal elements become inflated or swollen, and their cytoplasm becomes very dense. Such hyphae often separate into

short chains consisting of several cells. (Plate IX, Figure a).

Although this taxon appears to be closely related to Cylindrocarpon gracile Bugn., there are sufficient cultural differences, i.e. conidia and phialide size, and lack of chlamydospores, to justify it being described as a seperate species.

Culture - UM I (CMI)

17. Cylindrocarpon tax. sp. 2

(Plate IX, Figures b - i)

Isolated from beach-ridge soil, this taxon has not been previously described. Single conidia on PDA at 22 - 25° C produce a colony 34 - 36 mm in diameter after 10 days. Centre of colony raised and covered with coremia-like tufts of white mycelium. Mycelium from above buff colored, appressed, compact, shiny or wet appearing; folded or fissured in appearance, with the folds radiating from centre to 2 - 3 mm from edge, with superimposed buff-colored concentric rings 1 - 1.5 mm wide alternating with narrower (0.25 mm wide) honey-colored concentric rings. In reverse, colony buff with radiating folds or fissures. Conidia produced on simple lateral or terminal phialides on both aerial and emmersed mycelium.

Aerial phialides variable in shape; straight-sided to slightly tapered at both the proximal and distal ends; flask-shaped with narrow neck; or peg-like (Plate IX, Figures b and c) - phialides often becoming flexuous at the tip (Plate IX, Figure d) and occasionally proliferating (Plate IX, Figure e). Immersed phialides are more typical of Cylindrocarpon species; straight-sided to slightly tapering at base and tip and widest in middle. Conidia produced in masses surround the tip of

immersed phialides which bear a marked apical collarette (Plate IX, Figure f). Phialides 4 - 30 x 1.2 - 2.5 µ. Conidia with 0-1 septa (usually centrally located) occasionally up to 3 septate, cylindric to rod-shaped, straight-sided with acute proximal end and rounded distal end or straight-sided with acute ends. Conidia of young cultures are more uniform in shape, size and septation (cylindric, 0-1 septate) than those of older cultures which tend to become less cylindric (by developing acute apices), vary more in size, and may become multiseptate. Older conidia may also swell and become hour-glass shaped. Conidia measure 4 - 14.5 x 1.5 - 3 µ. No chlamydospores were observed in this isolate.

Culture - UM 3 (CMI)

18. Cylindrocarpon tax. sp. 3

(Plate X, Figures a - g; Plate XI, Figure a)

Isolated from marsh soil, isolates of this fungus represent an undescribed species of Cylindrocarpon. Single conidia on PDA at 22 - 25° C produce a colony 25 - 28 mm in diameter after 10 days. Colonies from above appearing flocculent to tufted; central region appearing slimy, umber in colour; progressing to margin, colony becomes light sienna with pale luteous rings of growth, finally white at margin; rings covered with slimy to waxy sporodochial spore masses. Colony in reverse has a central sienna region bounded by umber zone which becomes luteous to pale luteous at margin; concentric growth rings are superimposed over colored bands.

Conidia produced on simple lateral phialides or phialides of monopodial branching conidiophores which eventually form sporodochial masses (Plate X, Figure a). Phialides cylindric to tapering at their tip and bearing a marked apical collarette; 13 - 24 x 3 - 4 µ (Plate X,

Figures b - d). Conidia (0) 3 - 4 (5) septate, slightly clavate, curved, with rounded distal end tapering to smaller rounded proximal end; 38 - 75 x 5 - 7.5 µ (Plate X, Figures e - g). Chlamydospores produced after 2 - 3 weeks; smooth walled and globose; solitary or in chains or clusters; terminal, intercalary or lateral; hyaline; individual chlamydospores are 6 - 15 µ in diameter (Plate XI, Figure a).

Cultures - UM 10 - 13 (CMI) and UM 33 - 41 (CMI)

19. Cylindrocarpon tax. sp. 4

(Plate XI, Figures b - g)

Cultures of this isolate from beach-ridge soil fall within the taxonomic limits of the genus Cylindrocarpon, however they appear to represent an undescribed species. Single conidium transfers on PDA at 22 - 25° C produce colonies 22 - 26 mm in diameter after 10 days. Colonies, from above, appearing flocculent with abundant aerial mycelium; central region umber, merging into a zone of concentric growth, which is sienna to pale luteous, eventually white to off-white at margin. In reverse the colonies show concentric growth rings with the same coloration as above. After approximately 2 - 3 weeks umber-sienna colored hard stromatic pustules 1 - 1.5 mm across form in centre of colony. Sectioned pustules show an aggregated, rind-like exterior with a pseudoparenchyma-like core. Conidia produced on simple phialides, or bifurcate or trifurcate branched lateral or terminal phialides, or on phialides of branched conidiophores which eventually form sporodochia-like masses (Plate XI, Figure b). Phialides cylindric to slightly tapered at tip with an apical collarette; 16 - 33 x 2 - 2.5 µ (Plate XI, Figures c and d). Conidia 0 - 1 septate, with an approximately central septum;

cylindric to slightly tapered at the proximal end and truncate; 16 - 25 x 2.5 - 3.5 µ (Plate XI, Figures f and g). Chlamydospores abundant after 2 - 3 weeks; smooth walled and globose; 7 - 20 µ in diameter; solitary, in chains, or clustered; terminal, intercalary, or lateral; hyaline (Plate XI, Figure e).

Culture - UM 62 (CMI)

20. Cylindrocarpon tax. sp. 5

(Plate XII, Figures a - h)

Isolated from marsh soil this isolate represents a previously undescribed species of Cylindrocarpon.

Single conidia on PDA at 22 - 25° C produce colonies 19 - 27 mm in diameter after 10 days. Colonies from above showing abundant aerial mycelium in definite concentric circles with a well defined margin; central region umber grading through sienna-luteous, luteous to pale luteous to white within 6 mm of colony margin; agar pale luteous near margin. In reverse, colonies show concentric growth, grading from umber at centre to pale luteous at margin. Conidia borne on simple lateral phialides or on phialides of branching conidiophores which eventually form sporodochial masses (Plate XII, Figure a). Phialides cylindric to tapering at thin tips or doliform in shape; all possessing an obvious apical collarette; 11 - 21 x 2.5 - 3.5 µ (Plate XII, Figure b). Conidia 0 - 5 septate, curved, tapering slightly from rounded distal end to truncated proximal end; 50 - 65 x 6 - 7.5 µ (Plate XII, Figures g and h). Abundant chlamydospores produced after 2 - 3 weeks, smooth walled, globose, 7 - 15 µ in diameter; single, in chains or clustered; terminal, intercalary or lateral; hyaline (Plate XII, Figures c - e). This isolate of Cylindrocarpon appears to be most closely related

to the Cylindrocarpon ianthothele Wollenw. group of the currently accepted species of this genus (Booth, 1966).

Cultures - UM 118 (CMI) and UM 119 (CMI)

21. Dactylaria scaphoides Peach, 1942, Trans. Br. mycol. Soc. 35:19-20.

(Plate XIII, Figures a - f; Plate IX, Figure a)

Isolates obtained from marsh soil agree with Peach's (1952) description of this interesting nematophagous fungus.

It has not been previously reported from Manitoba.

Culture - UM 125 (DAOM)

22. Doratomyces nanus (Ehrenb. ex Link) Morton & Smith, 1963, Mycol. Pap. 86:80-82.

(Plate XIV, Figures b - g; Plate XV, Figures a and b)

Isolates obtained from marsh soil agree with the published description of this fungus.

It has not been previously reported from Manitoba.

Culture - UM 7 (CMI)

23. Doratomyces putredinis (Corda) Morton & Smith, 1963, Mycol. Pap. 86: 83-85.

As pointed out by Morton & Smith (1963), this fungus is difficult to place adequately because it is not really characteristic of the genus Doratomyces. None of our cultures produced any of the dematiaceous pigment normally considered to be characteristic for species of this genus and synnemata, while present, were normally quite sparse.

Isolates were obtained from marsh soil, but this organism has not been previously reported from Manitoba.

Culture - UM 126 (DAOM)

24. Emericellopsis sp.

(Plate X, Figures c - j)

This fungus has much smaller conidia than Emericellopsis minima Stolk (1955), although in many respects it seems similar to that species. It is possible our organism may be referable to either Emericellopsis pallida or Emericellopsis donezskii, both described as new species by Beljakova (1974), but we have been unable to obtain cultures of these two species for comparison. Our fungus does not seem to be identifiable with any of the other described species of Emericellopsis, although there is no doubt it clearly belongs in this genus.

Isolates were obtained from marsh soil, and there have been no published reports of the occurrence of members of the genus Emericellopsis from Manitoba previously.

Culture - UM 194 (CBS)

25. Fusarium arthrosporioides Sherb., 1915, Mem. Cornell Univ. agric. Exp. Stn. 6:175.

Isolates obtained from beach ridge soil conform precisely to Booth's (1971) published description of this fungus.

Published reports of the occurrence of this fungus in Manitoba (Bisby et al., 1938; Gordon, 1959) usually involve its presence on, or isolation from, plant parts. This is apparently the first report of its direct isolation from soil.

Cultures - UM 81 (CMI), UM 94 (CMI) and UM 117 (CMI)

26. Fusarium graminearum Schwabe, 1838, Fl. Anhaltina 2:285.

Isolates from marsh and beach ridge soil match published descriptions of this fungus (Booth, 1971).

Bisby et al. (1938) reported F. graminearum probably occurred in Manitoba, since its perfect state Gibberella zeae (Schw.) Petch (reported as Gibberella saubinetii) had been isolated on old corn stalks growing on the university field plots. It has been reported by Gordon (1944) from a variety of plant parts.

Cultures - UM 5 (CMI), UM 30 (CMI), UM 31 (CMI), UM 32 (CMI), and UM 88 (CMI)

27. Fusarium lateritium Nees, 1817, Syst. Pilze Schwämme:31.

Isolates obtained from beach-ridge soil conform closely with Booth's (1971) published description of this species.

Bisby et al. (1938) record a doubtful report of F. lateritium from twigs of Acer negundo L. in Manitoba, but it has been confirmed from Fraxinus sp. by Gordon (1959).

Cultures - UM 79 (CMI) and UM 86 (CMI)

28. Fusarium oxysporum Schlecht, 1824, Flora berol. 2:139 emend. Snyder & Hansen pro parte, Am. J. Bot. 27:64-67. 1940.

This organism, regularly isolated from beach-ridge soil, has long been known to be one of the commonest Fusaria in Manitoba soils (Bisby et al., 1938; Gordon, 1954).

Cultures - UM 91 (CMI), UM 92 (CMI) and UM 93 (CMI)

29. Fusarium poae (Peck) Wollenweber, 1913, in Lewis, Bull. Me agric. Exp. Stn. 219:254-258.

F. poae has been obtained previously in Manitoba from both soil and by direct isolations from various parts of a large variety of plants (Bisby et al., 1938; Gordon, 1959). During this study it was regularly

isolated from beach-ridge soil.

Cultures - UM 90 (CMI)

30. Fusarium semitectum Berk. & Rav., 1875, Grevillea 3:98.

Isolates from beach-ridge soil agree closely with the published description of this organism (Booth, 1971), which has been previously reported from parts of various Manitoba plant species (Gordon, 1959) and from soil (Gordon, 1954).

Culture - UM 213

31. Fusarium solani (Mart.) Sacc., 1881, Michelia 2:296, emend. Snyder and Hansen pro. parte, Am. J. Bot. 28:740. 1941.

This organism, routinely isolated from beach-ridge soil, has been isolated from a wide variety of Manitoba plant species and at least one insect (Bisby et al., 1938; Gordon, 1959) and from soil (Gordon, 1954).

Cultures - UM 82 (CMI), UM 83 (CMI) and UM 84 (CMI)

32. Fusarium sporotrichioides Sherb., 1915, Mem. Cornell Univ. agric. Exp. Stn. 6:183.

This species was isolated from beach-ridge soils, and has previously been reported as occasionally occurring in Manitoba soils by Bisby et al. (1938) and Gordon (1954).

Cultures - UM 65 (CMI), UM 77 (CMI), UM 85 (CMI), UM 87 (CMI) and UM 89 (CMI)

33. Fusarium tabacinum (Van Beyma) W. Gams, 1968, Persoonia 5:179.

This fungus was isolated from both marsh and beach-ridge soil and is doubtfully referred to this taxon. It seems to fall between Fusarium and Acremonium (Cephalosporium), and it is only by stretching

the species limit of F. tabacinum sensu Booth (Booth, pers. comm.) that my isolates can be accommodated herein. However, this seems to be the only readily available name at present, and in spite of the identification difficulty, my isolates are assigned here for the present.

This organism may have been previously reported from Manitoba under another name.

Cultures - UM 2 (CBS), UM 55 (CBS), UM 56 (CBS) and UM 57 (CBS)

34. Fusarium tricinctum (Corda) Sacc., 1886, Sylloge Fung. 4:700.

Isolates obtained from both the marsh and beach-ridge soils agree with the published descriptions of this organism (Booth, 1971).

F. tricinctum has not been previously reported from Manitoba.

Cultures - UM 28 (CMI), UM 29 (CMI), UM 67 (CMI), UM 68 (CMI), UM 96 (CMI), UM 97 (CMI), UM 98 (CMI), UM 99 (CMI), UM 100 (CMI) and UM 101 (CMI)

35. Fusidium cf. griseum Lk., 1809, Mag. Ges. naturf. Freunde, Berlin 3:6.

Isolates from marsh soil treated under this name appear to conform fairly well to various descriptions of this organism (e.g. Barron, 1968) except for the occurrence of the somewhat darker pigmentation than is normally reported for F. griseum.

The status of the genus Fusidium is in doubt (Booth, 1966), but as this appears to be the currently employed name, it is used herein.

F. griseum has not been previously reported from Manitoba.

Culture - UM 205 (DAOM)

36. **Gliocladium catenulatum** Gilman & Abbott, 1927, Iowa State Coll. Journ. Sci. 1:303.

(Plate XVI, Figures a - d)

Isolated from beach-ridge soil, G. catenulatum was previously reported on grass seed from Manitoba (Bisby et al., 1938).

Cultures - UM 47 (CBS) and UM 48 (CBS)

37. **Gliocladium roseum** Bain., 1907, Bul. Soc. Mycol. France 23:111-112

(Plate XVI, Figures e - h)

A fungus under this name was reported to be common in Manitoba soils by Bisby et al (1938). However, the precise identity of the isolates which we have referred to this species is somewhat doubtful. Our isolates have spores consistently slightly narrower than the spore width reported for G. roseum (more like those of G. catenulatum) but in other respects they resemble G. roseum.

Isolated from beach-ridge soil.

Cultures - UM 8 (CBS) and UM 192 (CBS)

38. **Gliomastix cerealis** (Karst.) Dickinson, 1968, Mycol. Pap. 115:19.

Isolated from marsh soil, G. cerealis has not previously been reported from Manitoba.

Culture - UM 53 (CMI)

39. **Hormiactus alba** Preuss, 1851, Linnaea 24:128.

(Plate XVII, Figures a and b)

Isolated from beach-ridge soil, H. alba was previously questionably reported by Bisby et al. (1938) on bark of Populus sp. in Manitoba.

It is questionable whether the isolates here referred to H. alba, really are that species sensu Preuss. Domsch & Gams (1970) state that H. alba Preuss (Herb. B) possesses phialospores, most current treatments state H. alba has blastospores, so the true identity of this taxon is in doubt. However, our isolates appear to conform to the current concept of H. alba, hence our use of this name.

Culture - UM 207 (DAOM)

40. **Kernia pachypleura** Malloch & Cain, 1971, Can. J. Bot. 49:864-866.

(Plate XVII, Figures c - g)

Isolated from beach-ridge soil, K. pachypleura has not been previously reported from North America. Malloch & Cain (1974) originally described this ascomycete, and its Scopulariopsis-like conidial state, from a culture established from African elephant dung collected in Uganda, Africa. The report of this organism from Manitoba constitutes a major extension in the known distribution of this fungus.

Cultures - UM 211 (TRTC) and UM 212 (TRTC)

41. **Mariannaea elegans** (Corda) Samson var. elegans Samson, 1974, Studies in Mycology 6:75-76.

(Plate XIX, Figures a - d)

Well known under the name Paecilomyces elegans (Corda) Mason and Hughes (Penicillium elegans Corda) this fungus which was isolated from marsh soil, has not been previously reported from Manitoba.

Culture - UM 121 (DAOM)

42. Mortierella alpina Peyronel, 1913, Diss. Padova. Abb. 86.

(Plate XVII, Figure h and Plate XVIII, Figures a - c)

Isolated from marsh and beach-ridge soils, M. alpina has not been previously reported from Manitoba.

Culture - UM 217

43. Mortierella hyalina (Harz) Gams, 1969, Nova Hedivigia 18:13.

(Plate XVIII, Figures d and e)

Isolated from beach-ridge soil, M. hyalina has not been previously reported from Manitoba.

Culture - UM 218

44. Myrothecium roridum Tode ex Fr., 1829, Syst. mycol. 3:217.

This extremely common organism (Tulloch, 1972) was isolated from both marsh and beach-ridge soils. It was previously reported as occurring on unidentified plant stems in Manitoba (Sutton, 1968); however, this fungus does not appear to have been previously isolated from Manitoba soils.

Culture - UM 66 (CMI)

45. Paecilomyces farinosus (Holm ex S. F. Gray) Brown & Smith, 1957, Trans. Brit. mycol. Soc. 40:50.

(Plate XIX, Figures e - h)

This relatively common organism (Bissett, 1979) has been widely isolated in Canada from a variety of substrates such as insects, soils, and rotten wood. However, this appears to be the first report of its occurrence in Manitoba, having been isolated from both the marsh and beach-ridge soils.

Cultures - UM 46 (CMI) and UM 58 (CBS)

46. Paecilomyces marquandii (Massee) Hughes, 1951, Mycological Paper 45:30.

(Plate XX, Figures a - e)

Isolated from both marsh and beach-ridge soils, this fungus has not previously been reported from Manitoba.

Cultures - UM 6 (CMI) and UM 59 (CMI)

47. Penicillium brevi-compactum Dierckx, 1901, Soc. Scient. Brux. 25.88.

Isolated from both marsh and beach-ridge soils, this fungus has previously been reported from butter in Manitoba (Bisby et al., 1938).

Cultures - UM 131 (CBS), UM 132 (CBS), UM 133 (CBS), UM 147 (CBS), UM 150 (CBS) and UM 163 (CBS)

48. Penicillium cf. canescens Sopp, 1912, Vidensk. Skrifter I. Mat. - Naturv. Klasse II:181-182.

(Plate XX, Figures f and g)

This fungus was isolated from both marsh and beach-ridge soils and, while clearly referable to P. canescens, the conidiophores of this isolate are only sparsely roughened (Plate XX, Figure f) when compared with typical isolates of this species. However, the phialides and the phialospores (Plate XX, Figure g) are characteristic of typical P. canescens.

Bisby et al. (1938) reported the occurrence of P. canescens in Manitoba soil.

Cultures - UM 145 (CBS), UM 146 (CBS), UM 148 (CBS), UM 151 (CBS and UM 167 (CBS)

49. **Penicillium** cf. **citrinum** Thom, 1910, U.S. Dept. Agr., Bur. Anim. Ind., Bull. 118:61-63.

(Plate XX, Figures h - j)

Isolates typical of P. citrinum possess phialospores which are described as being smooth or nearly so (Roper & Thom, 1968). The Manitoba isolates obtained during this study from beach-ridge soil have conidiophores and phialides characteristic for the species, but their phialospores are distinctly tuberculate (Plate XX, Figure j).

P. citrinum has not been previously reported in Manitoba.

Cultures - UM 142 (CBS), UM 144 (CBS), UM 160 (CBS), and UM 164 (CBS)

50. **Penicillium** cf. **claviforme** Bainier, 1905, Bull. Soc. mycol. Fr. 21:127.

This apparent strain of P. claviforme, isolated from both beach-ridge and marsh soil, has spores slightly smaller than those normally encountered in this species.

This is the first report of the occurrence of P. claviforme in Manitoba.

Culture - UM 129 (CBS) and UM 177 (CBS)

51. **Penicillium** cf. **damascenum** Bagdadi, 1968, Nov. Sist. niz. Rast. 1968:101.

(Plate XXI, Figures a - c)

Isolated from marsh and beach-ridge soils, this strain of P. damascenum does not have the characteristic smooth conidiophores reported for this species but, rather, it has coarsely roughened conidiophores (Plate XXI, Figures a and b) similar to those of Penicillium

roqueforti Thom (Raper & Thom, 1968). However, the phialides and phialospores appear to be quite typical of P. damascenum (Plate XXI, Figure c).

P. damascenum has not been previously reported in Manitoba.

Cultures - UM 134 (CBS), UM 135 (CBS), UM 140 (CBS), UM 141 (CBS), UM 149 (CBS), UM 165 (CBS), UM 168 (CBS) and UM 172 (CBS)

52. **Penicillium expansum** Link, 1809, Observationes Ord. Plant. nat. I:17.

Isolated from marsh and beach-ridge soils, P. expansum has previously been isolated from peat in Manitoba (Bisby et al., 1938).

Culture - UM 130 (CBS)

53. **Penicillium frequentans** Westling, 1911, Ark. Bot. 11:58, 133-134. 1911.

Isolated from marsh soil, P. frequentans has previously been reported from Manitoba soils (Bisby et al., 1938).

Culture - UM 178 (CBS)

54. **Penicillium janthinellum** Biourge, 1923, La Cellule 30:258-260. 1923

Isolated from beach-ridge soil, P. janthinellum is a well known soil inhabiting fungus in Manitoba (Bisby et al., 1938).

Culture - UM 139 (CBS)

55. **Penicillium jenseni** Zaleski, 1927, Bull. Acad. Polonaise Sci.:Math. et Nat. Ser. B:494-495.

Isolated from beach-ridge soils, this species has not been previously reported in Manitoba.

Cultures - UM 154 (CBS) and UM 157 (CBS)

56. Penicillium cf. jenseni Zaleski

(Plate XXI, Figures d - f)

Isolated from marsh soils, this apparent strain of P. jenseni, has uncharacteristically roughened conidiophores (Plate XXI, Figures d and e), and produces a bright yellow pigment which is visible on the reverse of the thallus. The phialides and phialospores, however (Plate XXI, Figure f), are quite typical of P. jenseni.

The true relationship of this strain to the typical P. jenseni is unclear.

Culture - UM 171 (CBS)

57. Penicillium nalgiovensis Laxa, 1932, Zentbl. Bakt. ParasitKde (Abt. II) 86:162-163.

Isolated from beach-ridge soil, P. nalgiovensis has not been previously reported in Manitoba.

Cultures - UM 137 (CBS), UM 138 (CBS) and UM 153 (CBS)

58. Penicillium nigricans (Bain.) Thom, 1930, The Penicillia, 351-353, The Williams & Wilkins Co., Baltimore, Md.

Isolated from both marsh and beach-ridge soils, this fungus has previously been reported from Manitoba forest soils (Bisby et al., 1938).

Cultures - UM 158 (CBS), UM 162 (CBS), UM 169 (CBS), UM 170 (CBS), UM 173 (CBS), and UM 175 (CBS)

59. Penicillium notatum Westling, 1911, Ark. Bot. 11:95-97.

Isolated from beach-ridge soil, P. notatum has not been previously reported in Manitoba.

Culture - UM 166 (CBS)

60. Penicillium oxalicum Currie & Thom, 1915, J. biol. Chem. 22:289.

Isolated from beach-ridge soil, P. oxalicum has previously been isolated from butter in Manitoba (Bisby et al., 1938), but this is the first report of its recovery from soil.

Culture - UM 152 (CBS)

61. Penicillium rolfsii Thom, 1910, U.S. Dept. Agr., Bur. Anim. Ind., Bull. 118:80-81.

Isolated from beach-ridge soil, P. rolfsii has not previously been reported in Manitoba.

Culture - UM 159 (CBS)

62. Penicillium roseo-purpureum Dierckx, 1901, Soc. Sci. de Bruxelles 25:86.

Isolated from beach-ridge soil, P. roseo-purpureum has not previously been isolated in Manitoba.

Cultures - UM 127 (CBS) and UM 161 (CBS)

63. Penicillium steckii Zaleski, 1927, Bull. Acad. Polonaise Sci.: Math. et Nat. Ser. B:469-471.

Isolated from beach-ridge soil, P. steckii has not previously been reported from Manitoba.

Cultures - UM 155 (CBS) and UM 156 (CBS)

64. Penicillium stoloniferum Thom, 1910, U.S. Dept. Agr., Bur. Anim. Ind., Bull. 118:68-69.

Isolated from marsh soil, P. stoloniferum has not previously been reported in Manitoba.

Culture - UM 176 (CBS)

65. Penicillium vinaceum Gilman & Abbott, 1927, Iowa State J. Sci. 1:299.

Isolated from beach-ridge soil, P. vinaceum has not previously been reported in Manitoba.

Culture - UM 128 (CBS)

66. Peziza ostracoderma Korf, conid. state, 1960, Mycologia 52:648-651.

(Plate XXIII, Figures a - d)

Isolated from beach-ridge soil, this organism has not previously been reported in Manitoba.

67. Phialophora fastigiata (Lagerb. & Melin) Conant, 1937, Mycologia 29:598.

(Plate XXI, Figures g and h)

Isolated from both marsh and beach-ridge soils during this study, this fungus was previously reported from Manitoba soils by Bisby et al. (1938) as Cadophora fastigiata Lagerb. and Melin.

Cultures - UM 198 (CBS) and UM 199 (CBS)

68. Phialophora malorum (Kidd & Beaum.) McColloch, 1944, Mycologia 36: 589.

(Plate XXI, Figure i and Plate XXII, Figures a and b)

Isolated from both marsh and beach-ridge soils, this organism has not previously been reported in Manitoba.

Culture - UM 197 (CBS)

69. Phialophora sp. nov.

(Plate XXII, Figures c - h)

Isolated from marsh soil, this fungus clearly represents an undescribed species of the genus Phialophora.

Cultures on quarter strength Potato Carrot agar (PCA), of floccose, loose aerial mycelium, not appressed to the agar; at first white in colour, becoming smoky-grey on aging. Conidiophores when present are inconspicuous, scattered or in small clusters on the aerial mycelium and bearing single or clusters of sporogenous cells at their apices; sporogenous heads consisting of fascicles of phialides. Phialides hyaline, subcylindric to slightly wider at their midpoint, with the distal end bearing a prominent collarette (3 - 6x2 - 2.5 u); entire phialide including collarette 9 - 18x2.5 - 3 u (Plate XXII, Figures c, d, e, and f). Phialospores of two types; first-formed spores fully endogenous within the enclosed tip of the phialide, cylindric to slightly clavate to occasionally slightly constricted in the middle and measuring 4 - 7x1 - 1.5 u (Plate XXII, Figure g). After rupture of the phialide tip, the first formed spore is released thus creating the prominent collarette (Plate XXII, Figure c). Secondary spores are subglobose to elliptic, and measure 1.5 - 2x1 - 2 u, with an apiculus remaining at the point where the spore was attached to the phialide (Plate XXII, Figure h). Secondary phialospores appear to be enclosed in a gelatinous sheath, and they aggregate in gloeoid masses about

the collarette.

Culture - UM 196 (CBS)

70. Phoma fimeti Brunaud, 1889, Bull. Soc. bot. Fr. 36:338. 1889.

Isolated from beach-ridge soils, this species has not previously been reported from Manitoba.

P. fimeti was originally described from sheep dung in France, but the original material was not preserved. Based on the fact that most coprophilous fungi commonly occur in soil and that she had a soil isolate which closely resembled Brunaud's published description, Dorenbosch (1970) designated a typical soil-isolate (dried) as a neotype for this name. It is, therefore, always possible that P. fimeti sensu Brunaud could be different from P. fimeti sensu Dorenbosch.

Culture - UM 15 (CMI)

71. Phoma glomerata (Corda) Wollenw. & Hochapf., 1936, Z. ParasitKde 8: 592.

As pointed out by Dorenbosch (1970), P. glomerata is relatively easy to identify because of its production, in culture, of chains of dictyospore-like chlamydospores.

This organism is newly reported here from Manitoba.

Culture - UM 16 (CMI)

72. Plenodomus sp. nov.

This isolate is a pycnidial form producing relatively massive pycnidia, with multiple ostioles on elongate necks.

It appears to be an undescribed species of Plenodomus

(E. Punitholingam, pers. comm.). However Sutton (1977) and Boerema & Kesteren (1963) suggest that this genus should be reduced to synonomy with Phoma Sacc.. If so, the disposition of this isolate should probably be placed in Phoma.

Culture - UM 24 (CMI)

73. Pyrenochaeta acicola (Lév.) Sacc., 1884, Sylloge Fung. 3:220.

The original type material of this name was not preserved and the name is now based on a neotype designated by Dorenbosch (1970).

The original description is quite vague, and it is possible Léveillé's fungus represented a rather different organism than that presently treated as P. acicola.

Isolated from beach-ridge soils, P. acicola sensu Dorenbosch has not been previously reported from Manitoba.

Culture - UM 14 (CMI)

74. Pyrenochaeta sp. nov. (?)

The isolates placed under this name clearly key to this genus. The pycnidia are setose, and the sporogenous cells, which line the inner wall of the pycnidium, are almost indistinguishable from the inner pycnidial wall cells, but they are, indeed, phialides.

The spores which are produced are hyaline, cylindric, 1- to 2-celled, and 10-12 x 2-2.5 μ.

This species is clearly different from the common soil borne species P. acicola (Lév.) Sacc. and P. terrestris (Hansen) Gorenz et al.,

but whether it truly represents an undescribed species cannot be proven.

There does not appear to be any record of a fungus which fits this description having been previously reported from Manitoba.

Culture - UM 45 (CMI)

75. Rhinocladiella cf. anceps (Sacc. & Ell.) Hughes, 1958, Can. J. Bot. 36:801.

(Plate XXIII, Figures e - i)

Isolated from marsh soil, this strain of Rhinocladiella anceps has larger blastospores than normally reported for this species (Plate XXIII, Figure i). However, the proliferating conidiophores and other features of this strain are typical of those of Rhinocladiella anceps (Plate XXIII, Figures e - h), so this isolate is considered to represent a slightly variant form of R. anceps.

This species has not been previously reported in Manitoba.

Culture - UM 124 (DAOM)

76. Rhinocladiella mansonii (Castell.) Scholl-Schwarz, 1968, Antonie van Leeuwenhoek 34:122-123.

(Plate XXIV, Figures a - d)

This is an extremely variable species; depending upon the isolate it may produce sympodioconidia, blastospores, phialospores, or thick-walled fragmenting hyphal elements, and all of these may act as reproductive units.

Isolated from both marsh and beach-ridge soils, this species has not previously been reported as occurring in Manitoba.

Culture - UM 195 (CBS)

77. Sporothrix sp.

(Plate XXIV, Figure e)

In the present state of the taxonomy of this genus, it is difficult for non-specialists to clearly differentiate species of Sporothrix which do not have an associated perfect state for reference. There are a number of such accepted species which seem to differ but little, and one might question such species delimitation. Further, some related genera are very similar to Sporothrix, and one can have difficulties deciding to which genus specimens should be referred. For example, Calcarisporiella de Hoog is separated from Sporothrix only because of the properties of the conidiiferous rachids and the shape of the conidiogenous cells.

While some species of Ceratocystis reported from Manitoba have Sporothrix-like states, there are no previous reports of Sporothrix species from Manitoba soils.

Culture - UM 200 (CBS)

78. Sporotrichum epigaeum Brun. var. terrestre Daszewska, 1912, Bull. Soc. Bot. Geneva II, 4:294.

(Plate XXIV, Figures f - h)

This organism has not been previously recorded from Manitoba.

Cultures - UM 201 (DAOM), UM 203 (DAOM), UM 204 (DAOM) and UM 206 (DAOM)

79. Stachybotrys cf. atra Corda, 1837, Icon. Fung. I:21.

(Plate XXV, Figures a - d)

Isolated from both marsh and beach-ridge soils, this strain of

S. atra has larger phialospores than normally reported for this species. However, both the conidiophores and phialides agree with published descriptions of S. atra, and the present isolate is probably just a variant thereof.

Sutton (1973) reported S. atra from Manitoba soils.

Cultures - UM 179 (DAOM) and UM 180 (DAOM)

80. Taxonomic genus #1

(Plate XXV, Figures e - g; Plate XXVI, Figures a - c)

Isolated from both marsh and beach-ridge soils, this fungus does not appear to be easily assignable to any established taxon. A number of its characteristics fall between those of Trichoderma and Verticillium.

Cultures on quarter-strength PCA appearing granular to somewhat scurfy in surface view; on Malt Extract agar (MEA) the cultures become somewhat more floccose. Marked diurnal ringing apparent only on PCA; this only slightly visible on MEA. On both agars the cultures appear chalky-white from above with a slightly pink centre about the point of inoculation; on MEA the cultures appear slightly yellow in reverse. Conidiophores, when present, quite well developed; erect; branching. Phialides solitary or arranged in a subverticillate manner on the branching conidiophores; variable; short flask-shaped and broadest above the base then tapering to their point of attachment, or broadest at the base and straight sided, tapering regularly to a narrow tip; (Plate XXV, figures f and g, or Plate XXVI, Figures a and b, respectively); 5-18 x 1-2 µ. Phialospores variable depending upon the plane of view; oval to almost

spherical to limoniform in one plane or flattened on one side and straight to slightly concave on the other side in the second plane of view (Plate XXVI, Figure c); usually attached eccentrically to the phialide at maturity (Plate XXV, Figure g); 1.5 - 2.5 x 1 - 1.5 µ.

Culture - UM 69

81. Trichoderma hamatum (Bon.) Bain aggr. sensu Rifai, 1969, Mycol. Pap. 116:22-31.

Isolated from marsh and beach-ridge soils, T. hamatum has not been previously reported from Manitoba.

Culture - UM 50 (CMI)

82. Trichoderma harzianum Rifai aggr., 1969, Mycol. Pap. 116:38-42.

Isolated from marsh and beach-ridge soils, T. harzianum has not been previously reported from Manitoba.

Cultures - UM 51 (CMI) and UM 52 (CMI)

83. Trichoderma polysporum (Link ex Pers.) Rifai aggr., 1969, Mycol. Pap. 116:18-22.

Isolated from beach-ridge soil, it is quite possible that this organism is what was earlier reported from Manitoba as Trichoderma album Preuss (Bisby et al., 1938). However, as pointed out by Rifai, no one really knows what T. album represents since Preuss' specimen has never been restudied, and many earlier specimens identified as T. album have been reidentified as T. polysporum.

Culture - UM 214

84. Trichoderma viride Pers ex S. F. Grey aggr. sensu Rifai, 1969, Mycol. Pap. 116:47-53.

Isolated from marsh soils, T. viride was previously reported from Manitoba soils by Bisby et al. (1938) as Trichoderma lignorum Tode ex Harz.

Culture - UM 215

85. Trichosporon sp.

(Plate XXVI, Figures d and e)

This fungus was isolated from beach-ridge soil and appears to fit fairly well within this genus. However, it was impossible to refer it to any species and because some Trichosporon sp. are reported to be human pathogens, a detailed study of this organism was not pursued.

Culture - UM 76 (ALTA)

86. Trichurus spiralis Hasselbring, 1900, Bot. Gaz. 29:321.

(Plate XXVI, Figures f - i; Plate XXVII, Figures a and b)

Isolated from marsh soil, T. spiralis has not been previously reported from Manitoba.

Culture - UM 216

87. Ulocladium atrum Preuss, 1852, Linnaea 25:75.

(Plate XXVII, Figures c - g)

Isolated from beach-ridge soil, this species has not been previously reported in Manitoba.

Culture - UM 74

88. **Verticillium dahliae** Klebahn, 1913, Mycol. Centralb. 3:66.

Isolated from marsh soil, V. dahliae has been reported from wilted elm and from poplar in Manitoba by Ives et al. (1968) and Sutton (1973).

Culture - UM 23 (CMI)

89. **Verticillium lamellicola** (F.E.V. Smith) W. Gams, 1971, Cephalosporium-artige Schimmelpilze:183-184.

(Plate XXVIII, Figures d and e)

This organism which is not commonly isolated from soil was obtained from both marsh and beach-ridge soils. This is the first report of this fungus from Manitoba.

Cultures - UM 106 (CBS), UM 107 (CBS) and UM 108 (CBS)

90. **Verticillium lecanii** (Zimm.) Viégas, 1939, Rev. Inst. Cafe Sâo-Paulo 14:754.

(Plate XXVIII, Figures f and g)

Although widely reported from a variety of substrates, V. lecanii, like V. lamellicola, is rarely reported as being directly isolated from soil. It has not previously been recorded from Manitoba.

Cultures - UM 109 (CBS) and UM 110 (CBS)

91. **Verticillium nigrescens** Pethybridge, 1919, Trans. Br. mycol. Soc. 6:177.

Isolated from marsh and beach-ridge soils, V. nigrescens has not been previously reported in Manitoba.

Cultures - UM 18 (CMI), UM 19 (CMI), UM 61 (CBS), UM 181 (CBS), UM 184 (CBS), and UM 191 (CBS)

92. Verticillium tenerum (Nees ex Pers.) Link, 1824, Linn. Spec. Plant 1:75.

(Plate XXIX, Figures c and d)

Isolated from marsh and beach-ridge soils, this is the first report of this organism occurring in Manitoba.

Culture - UM 111 (CBS)

93. Verticillium tax. sp. 1

(Plate XXVIII, Figure h; Plate XXIX, Figures a and b)

While, to date, this organism is not referable to any of the presently accepted species of Verticillium, it clearly belongs in that genus.

It is possible it may represent a new species isolated from marsh soil.

Culture - UM 190 (CBS)

94. Verticillium tax. sp. 2

(Plate XXVIII, Figures a - c)

Isolated from beach-ridge soil, the specific identity of this fungus remains unclear. This isolate has cultural characteristics common to some species of both Acremonium and Verticillium but it appears to be most closely related to Verticillium albo-atrum Runke & Berthold. However, sufficient differences probably exist to warrant separate status for this isolate.

Culture - UM 185 (CBS)

95. Volutella ciliata (Alb. & Schw.) Fr., 1832, Systema Mycol. 3:467.

(Plate XXIX, Figures e - g; Plate XXX, Figure a)

Isolated during this study from beach-ridge soil, V. ciliata was previously tentatively identified as occurring on Fraxinus in Manitoba by Bisby et al. (1938); there are no previous reports of V. ciliata from Manitoba soil. The actual nomenclature of this species is in doubt since Hughes (1958) noted that V. ciliata (Alb. & Schw.) Fr. is illegitimate.

Culture - UM 208 (DAOM)

96. Volutella sp.

(Plate XXX, Figures b - d)

Isolated from beach-ridge soil, this Volutella species is most likely either Volutella gilva (Pers. ex Fr.) Sacc. or Volutella roseola Cooke, but since no type material nor accurate description of these species was seen, specific identification is incomplete.

Bisby et al. (1938) reported V. roseola from soil in Manitoba. It should be noted that both of these names are nomina illegitima (Hughes, 1958).

Culture - UM 209 (DAOM)

97. Wardomyces anomalus Brooks & Hansf., 1923, Trans. Br. Mycol. Soc. 8: 135-137.

(Plate XXX, Figures e - g)

Isolated from beach-ridge soil, Wardomyces anomalus has not been previously reported in Manitoba.

PLATES

PLATE I

Acremonium crotocinigenum (Schol-Schwarz) W. Gams (Figures a-c)

Figure a. Phialide with phialospore (x 800)

Figure b. Phialospores (x 2000)

Figure c. Intercalary and terminal chlamydospores (x 2000)

Acremonium furcatum (F. & R. Moreau) ex W. Gams (Figures d-h)

Figure d. Simple phialides with phialospores (x 800)

Figure e. Branched schizophialide (x 800)

Figure f. Proliferating schizophialide; (arrow - original conidiogenous site) (x 1700)

Figure g. Branched schizophialide (x 1700)

Figure h. Phialospores (x 2000)

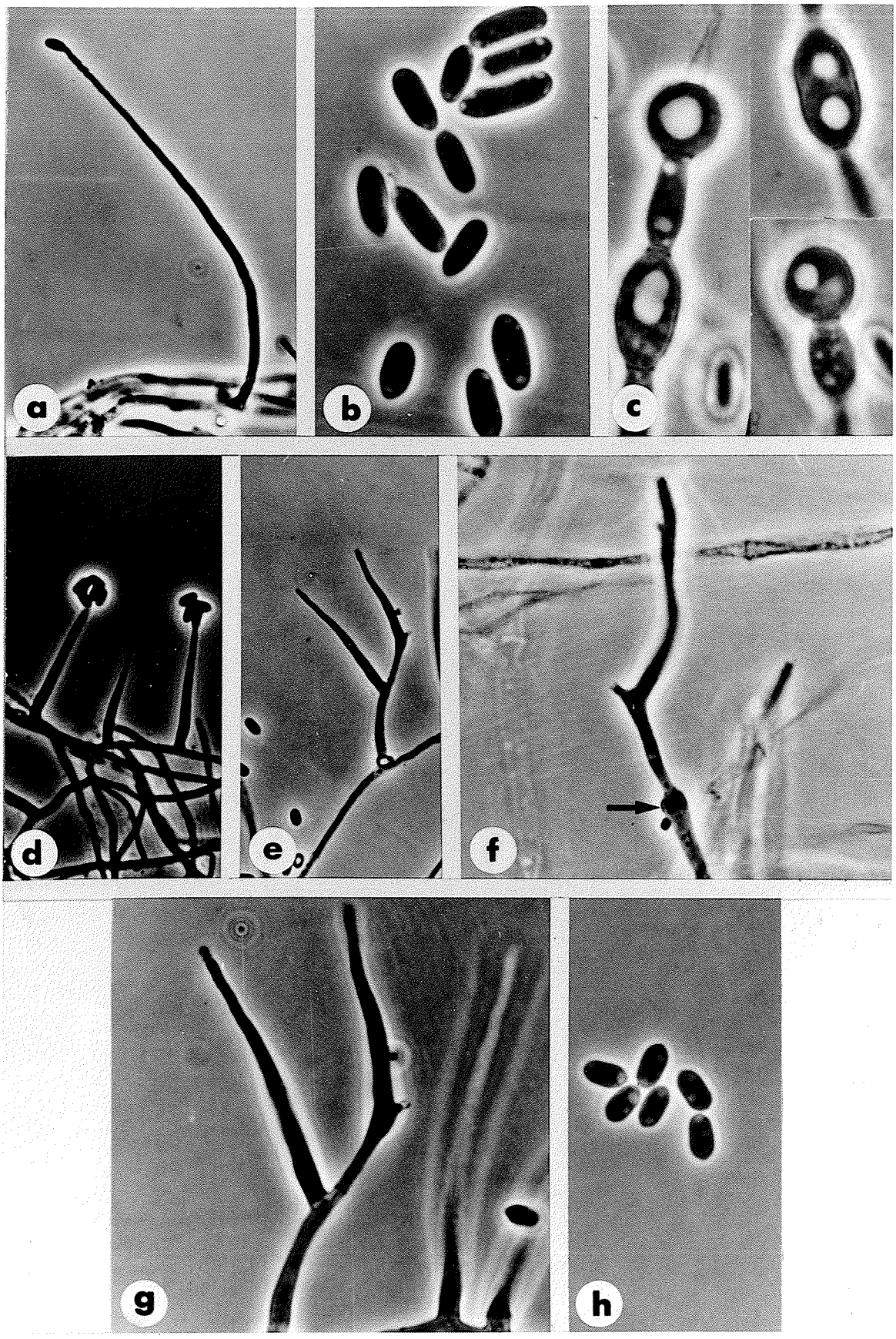

a
b
c
d
e
f
g
h

PLATE II

Acremonium persicinum (Nicot) W. Gams (Figures a and b)

Figure a. Simple phialides producing immature and mature phialospores (x 800)

Figure b. Phialospores (x 2000)

Acremonium sclerotigenum (F. & R. Moreau ex Valenta) W. Gams (Figures c and d)

Figure c. Simple phialides (x 800)

Figure d. Phialospores (x 2000)

Acremonium strictum W. Gams (Figures e and f)

Figure e. Simple phialides (x 800)

Figure f. Phialospores (x 2000)

Arthrinium phaeospermum (Corda) M. B. Ellis (Figures g - i)

Figure g. Blastoconidia with germ slits (x 1000)

Figure h. Conidiophore mother cell with blastospores (x 2000)

Figure i. Blastoconidia with germ slit (arrow) (x 2000)

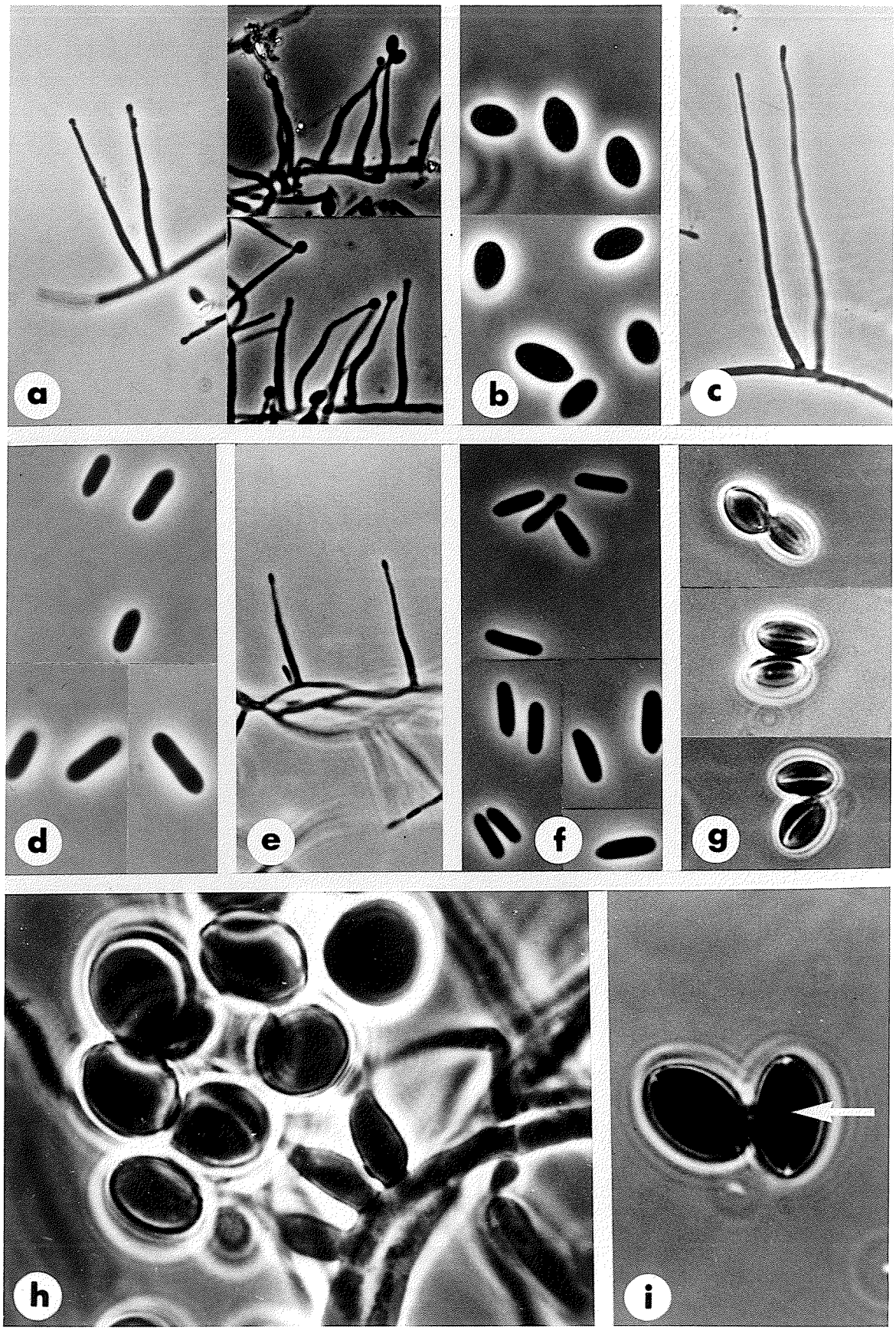

a
b
c
d
e
f
g
h
i

PLATE III

Arthroderma curreyi Berk. conidial state (Figures a - c)

Figure a. Habit (x 750)

Figure b. Aleuriospores showing attachment to mycelium (x 2400)

Figure c. Aleuriospores showing characteristic truncate base

Ascodesmis sphaerospora Obrist (Figures d - i)

Figure d. Immature apothecium (x 260)

Figure e. Mature apothecium (x 260)

Figure f. Immature asci with ascospores (x 650)

Figure g. Mature asci with ascospores (x 650)

Figure h. Ornamented ascospores. In surface plane of focus, ornamentations appear as ridges.

Figure i. Ornamented ascospores. In median plane of focus, ornamentations appear as peg-like projections.

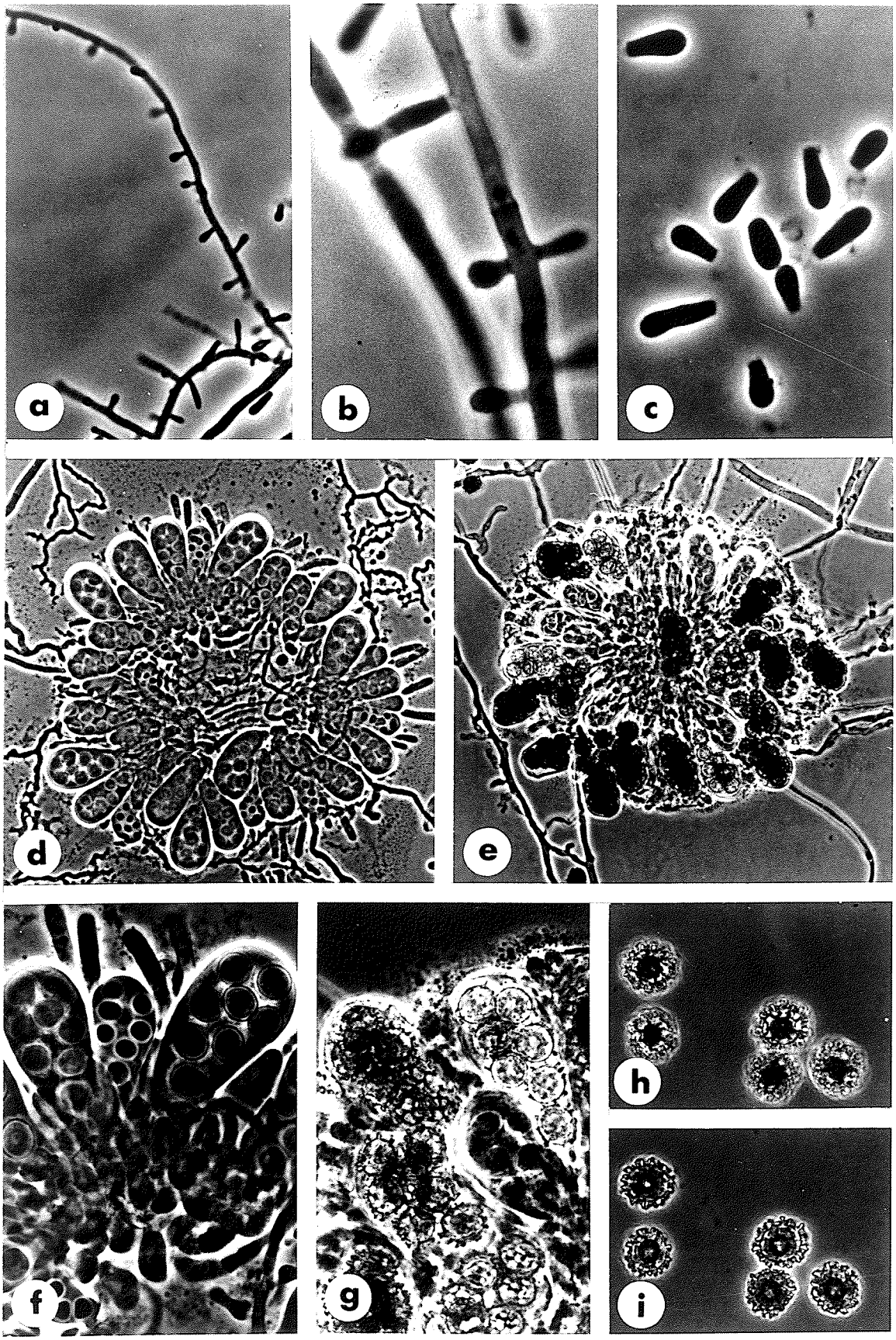

a
b
c
d
e
f
g
h
i

PLATE IV

Beauveria bassiana (Bals.) Vuill. (Figures a - d)

Figure a. Habit (x 350)

Figure b. Sympodulae; basal sporogenous cells showing various stages of development of acropetalous blastic sympodulospores (x 850)

Figure c. Blastic sympodulospores (x 2000)

Figure d. Sympodular sporogenous cells with denticulate rachis-like spore-bearing tips (x 2000)

Botryotrichum piluliferum Sacc. & March. (Figures e - g)

Figure e. Habit (x 350)

Figure f. Vegetative hyphae with immature aleuriospores (x 1000)

Figure g. Vegetative hyphae with mature aleuriospores (x 1000)

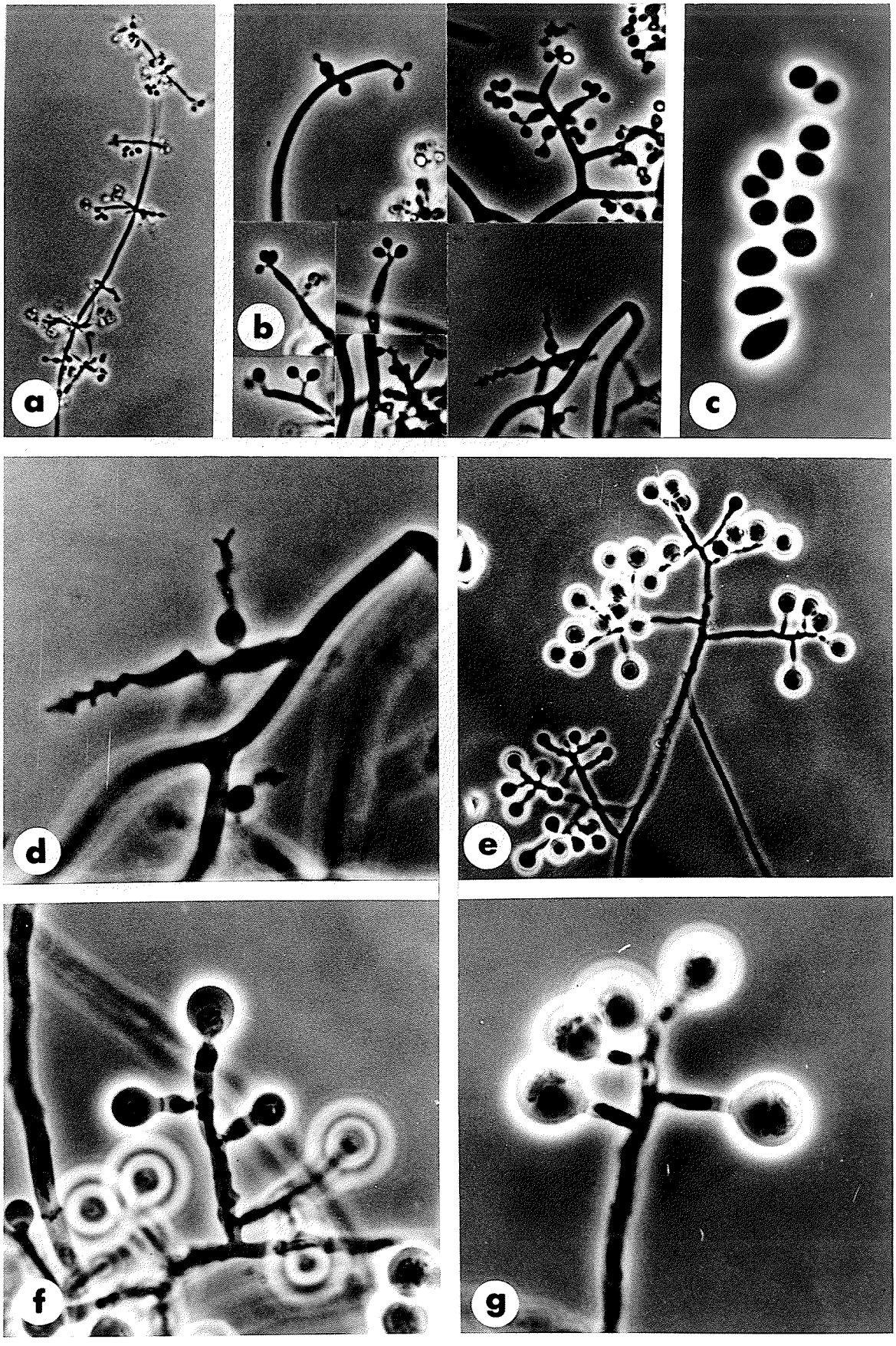

a
b
c
d
e
f
g

PLATE V

Botryotrichum piluliferum Sacc. & March. (Figures a and b)

Figure a. Aleuriospore and attached separating cell (arrow) (x 2000)

Figure b. Aleuriospores (x 450)

Botrytis cinerea Pers. ex Fr. (Figures c - g)

Figure c. Branching conidiophore with ampullae and very young blastospores (radulospores) (x 350)

Figure d. Ampullae and mature blastospores (radulospores) (x 350)

Figure e. Ampullae with blastospore (radulospore) initials (x 1000)

Figure f. Ampullae with young blastospores (radulospores) (x 1000)

Figure g. Blastospores (radulospores) showing attachment scar (arrow) (x 1000)

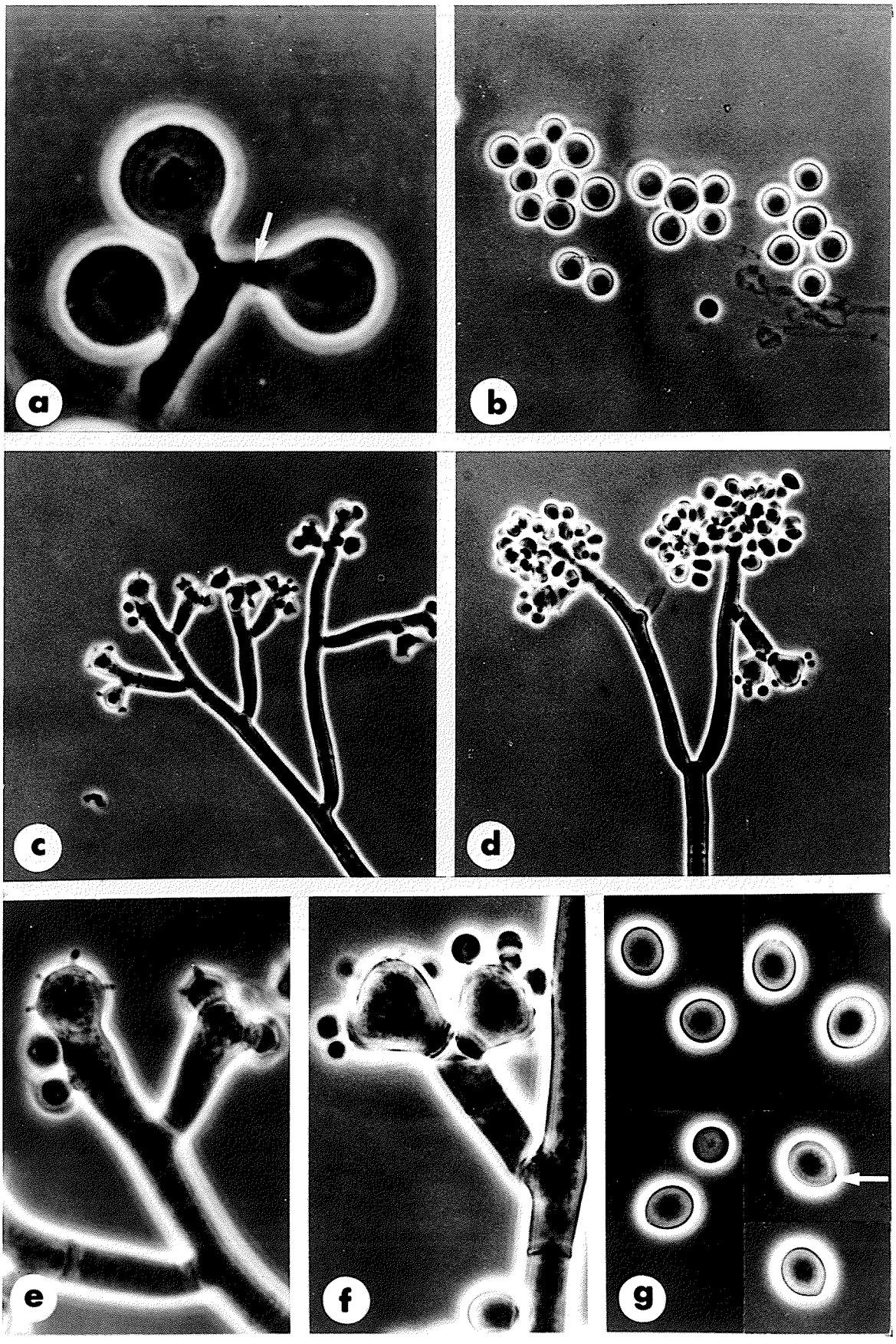

a
b
c
d
e
f
g

PLATE VI

Chaetomium funicolum Cooke (Figures a - d)

Figure a. Perithecium (x 250)

Figure b. Setae showing echinulations (x 650)

Figure c. Base of setae (x 650)

Figure d. Ascospores (x 2000)

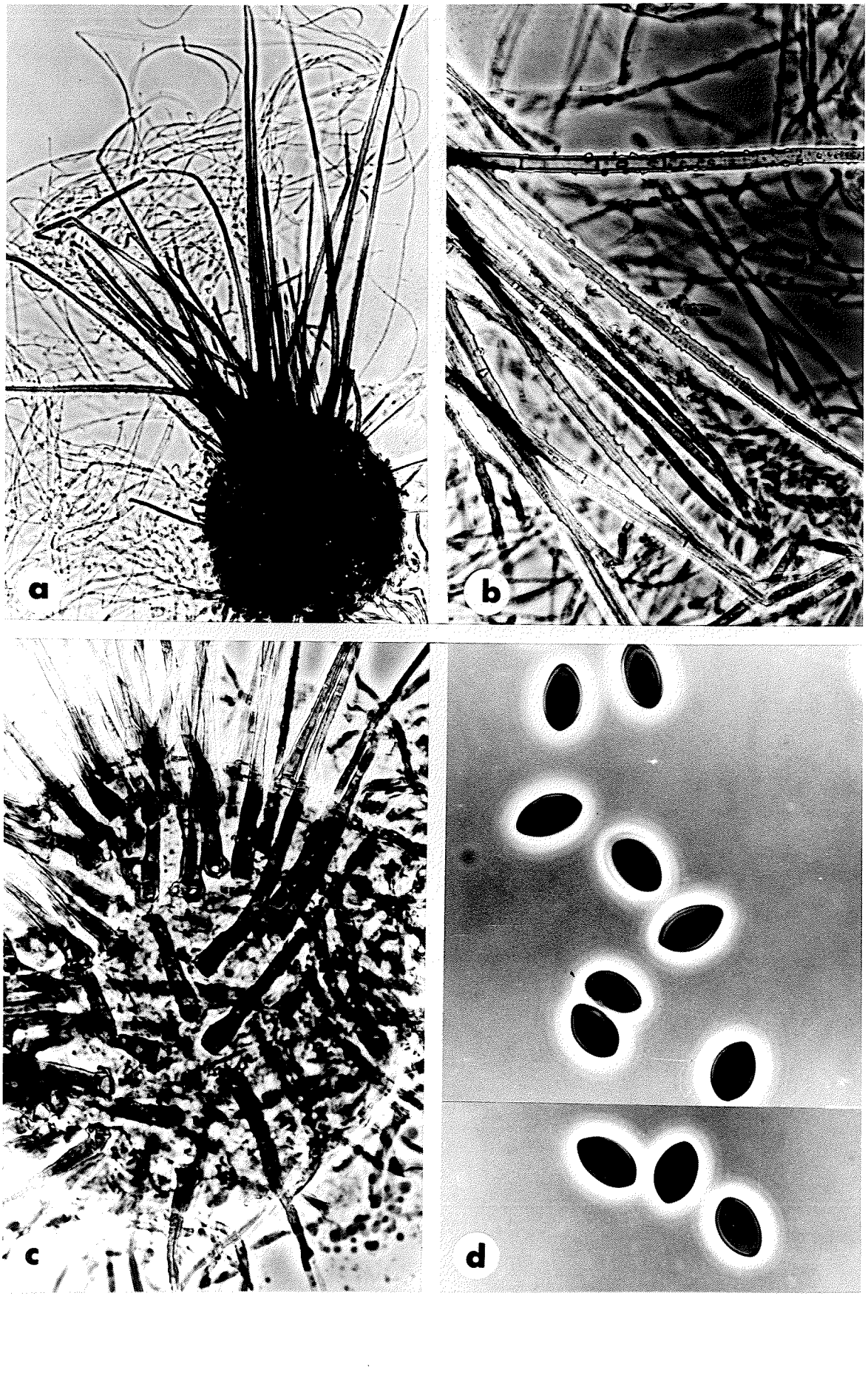

a
b
c
d

PLATE VII

Chrysosporium merdarium (Link ex Fr.) Carmichael var. roseum W. Gams (Figures a - c)

Figure a. Habit (x 350)

Figure b. Branching vegetative hyphae bearing arthrospores and aleuriospores (x 1000)

Figure c. Echinulate aleuriospores (x 2000)

Chrysosporium pannorum (Link) Hughes (Figures d - f)

Figure d. Habit (x 350)

Figure e. Vegetative hyphae bearing arthrospores and aleuriospores (x 2000)

Figure f. Echinulate arthrospores and aleuriospores (x 2000)

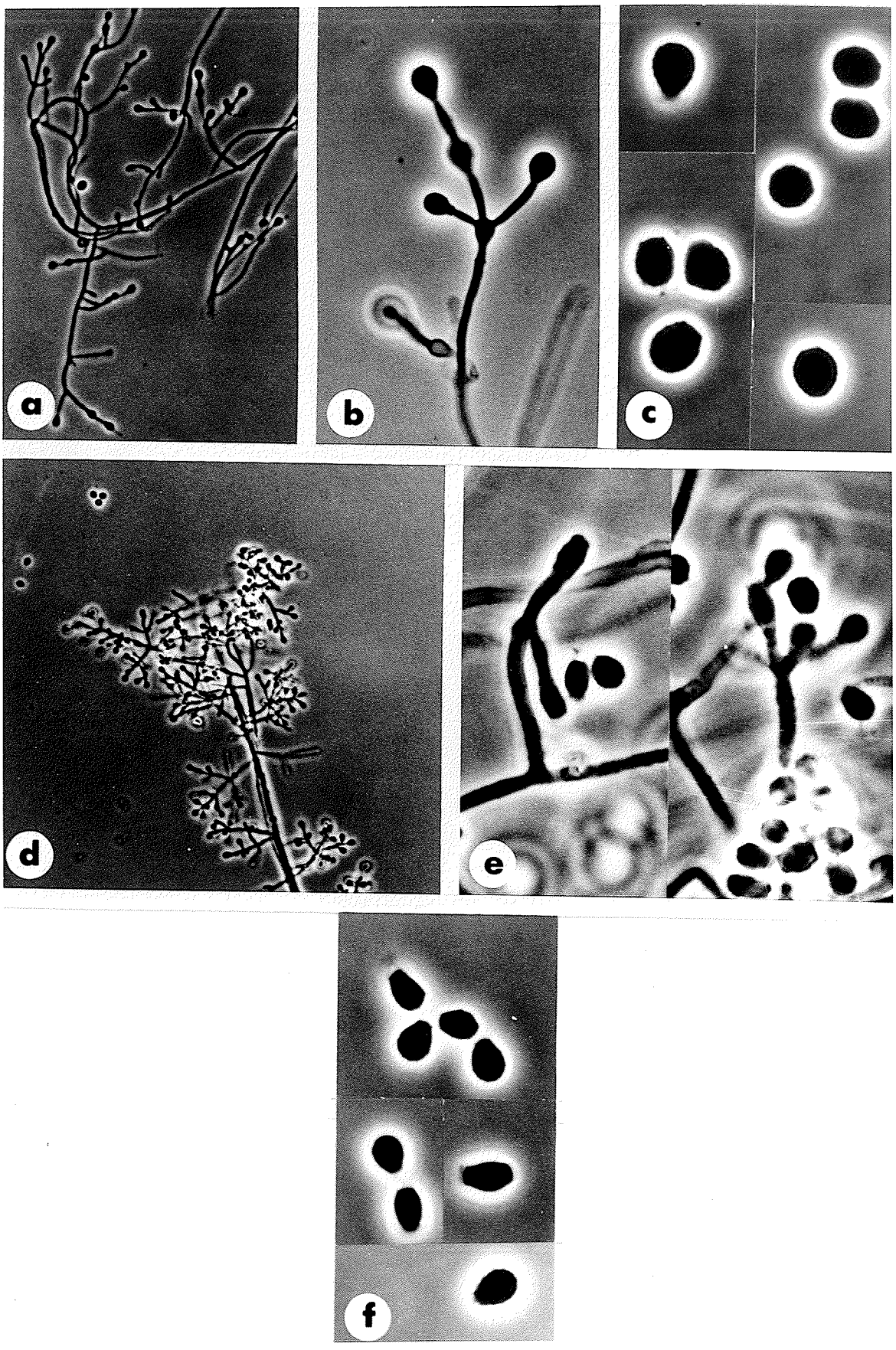

a
b
c
d
e
f

PLATE VIII

Cylindrocarpon tax. sp. 1 (Figures a - f)

Figure a. Habit (x 650)

Figure b. Simple lateral phialides bearing phialospores (x 1000)

Figure c. Branched conidiophores bearing phialides and phialospores. Branches simple to aggregated into sporodochium-like masses (x 1000)

Figure d. Branched conidiophore with phialides and phialospores showing development of new branch (arrow) (x 2100)

Figure e. Phialospores (x 1000)

Figure f. Phialospores (Interference Contrast) (x 1100)

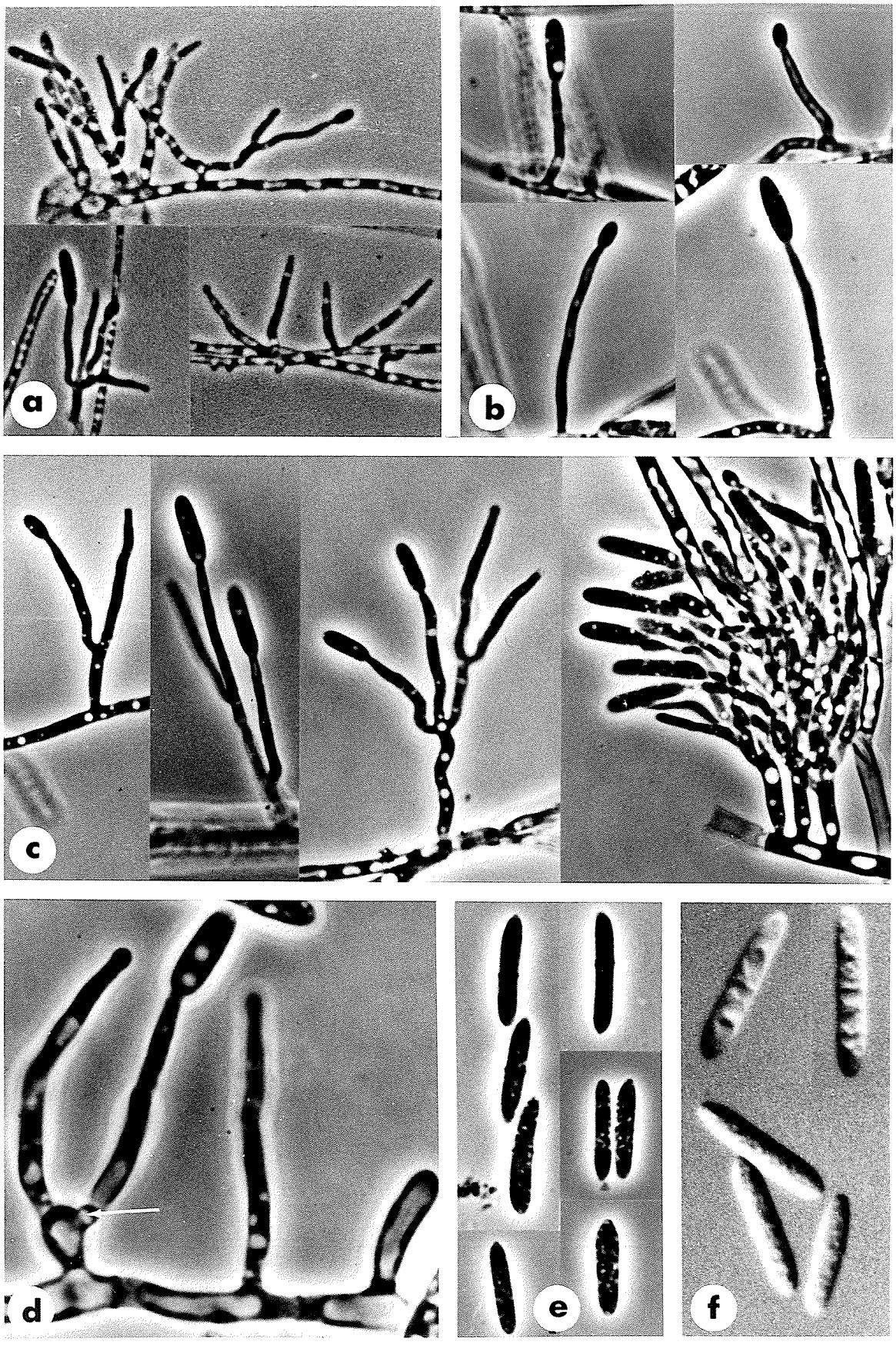

a
b
c
d
e
f

PLATE IX

Cylindrocarpon tax. sp. 1 (Figure a)

Figure a. Aged mycelium showing separated chains of swollen, dense, hyphal cells. (Interference Contrast) (x 800)

Cylindrocarpon tax. sp. 2 (Figures b - i)

Figure b. Habit (x 650)

Figure c. Phialides (x 1500)

Figure d. Phialide showing flexuous tip (x 1500)

Figure e. Proliferating phialide (x 1500)

Figure f. Immersed phialides from agar with phialospore mass; prominent collarette flanks tip of phialides (arrow) (x 1500)

Figure g. Terminal and lateral phialides with phialospores (x 1500)

Figure h. Phialospores (x 1500)

Figure i. Phialospores (Interference Contrast) (x 2300)

a
b
c
d
e
f
g
h
i

PLATE X

Cylindrocarpon tax. sp. 3 (Figures a - g)

Figure a. Gross mount showing simple lateral phialides, branched conidiophores with phialides producing phialospores, and branched conidiophores with phialides producing phialospores forming young sporodochial mass.(x 640)

Figure b. Phialospore development (x 2000)

Figure c. Simple lateral phialides; branched conidiophore with phialides and phialospores (Interference Contrast) (x 625)

Figure d. Phialides with phialospores; prominent collarettes flank phialide tips (arrow) (Interference Contrast) (x 1600)

Figure e. Phialospores (x 550)

Figure f. Phialospores (Interference Contrast) (x 625)

Figure g. Phialospores (Interference Contrast) (x 700)

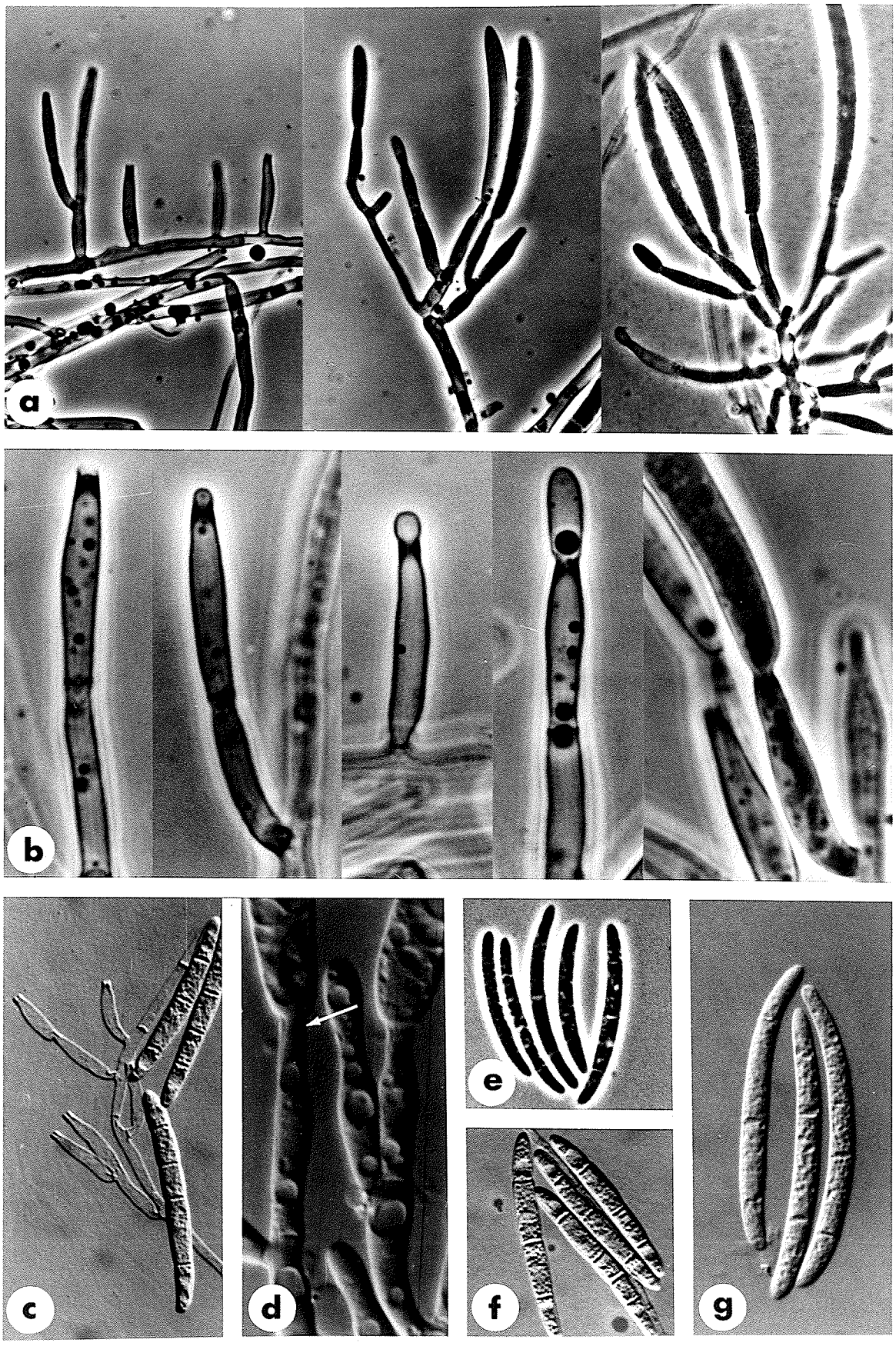

a
b
c
d
e
f
g

PLATE XI

Cylindrocarpon tax. sp. 3 (Figure a)

Figure a. Intercalary chains, intercalary clusters and terminal chlamydospores (Interference Contrast) (x 1600)

Cylindrocarpon tax. sp. 4 (Figures b - g)

Figure b. Habit (x 640)

Figure c. Branched terminal phialides bearing phialospores (x 1900)

Figure d. Simple lateral phialides bearing phialospores (x 1900)

Figure e. Chlamydospore arrangements including intercalary chains, terminal chains, terminal clusters, and intercalary clusters (Interference Contrast) (x 1600)

Figure f. Phialospores (x 1100)

Figure g. Phialospores (Interference contrast) (x 1100)

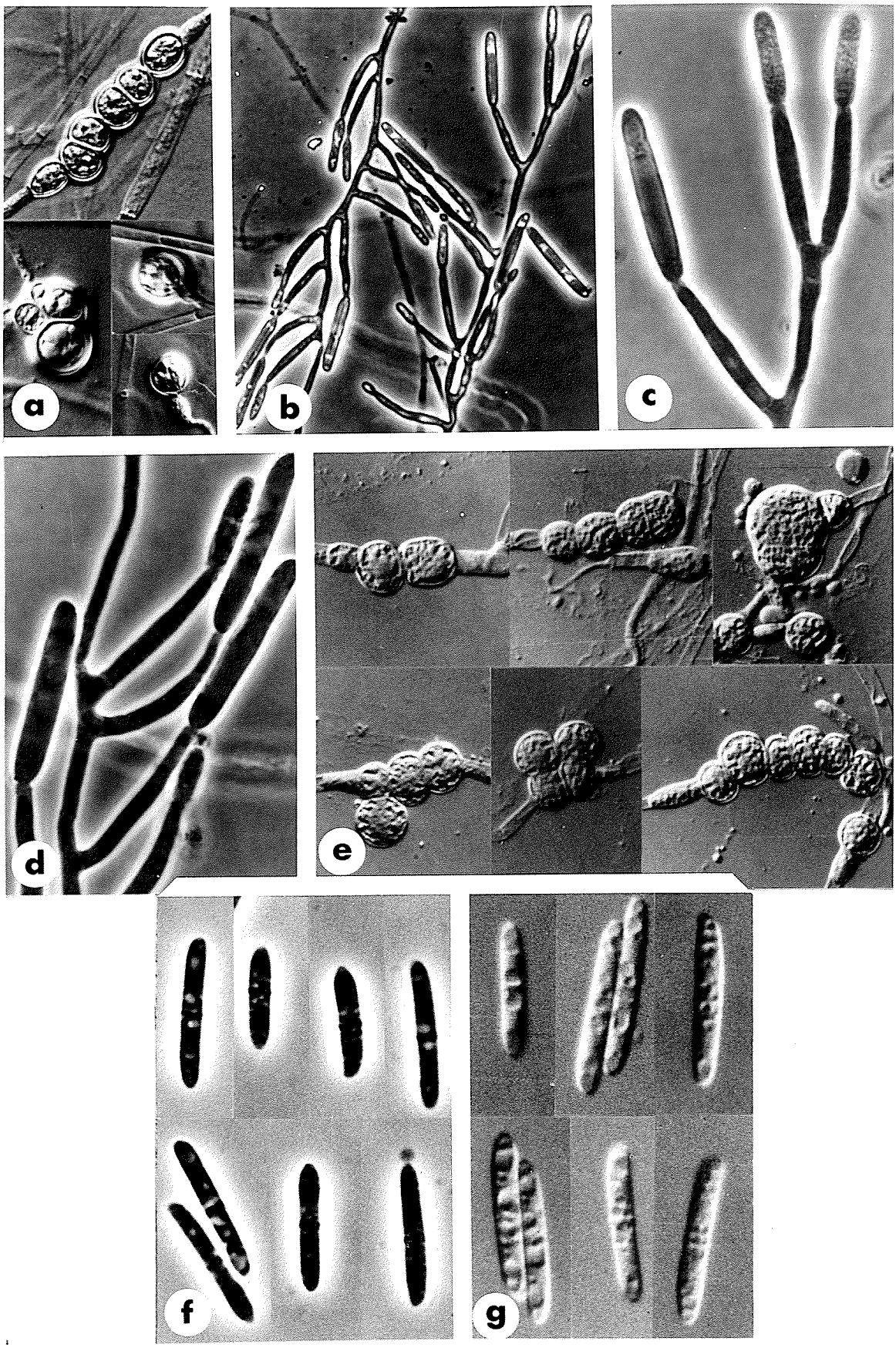

a
b
c
d
e
f
g

PLATE XII

Cylindrocarpon tax. sp. 5 (Figures a - h)

Figure a. Habit (x 350)

Figure b. Branched conidiophore with phialides bearing mature and immature phialospores (x 1000)

Figure c. Lateral chained chlamydospores - development (x 800)

Figure d. Intercalary clustered chlamydospores - development (x 800)

Figure e. Terminal chlamydospore (x 800)

Figure f. Intercalary clustered chlamydospores (Interference Contrast) (x 910)

Figure g. Phialospores (x 1100)

Figure h. Phialospores (Interference Contrast) (x 1100)

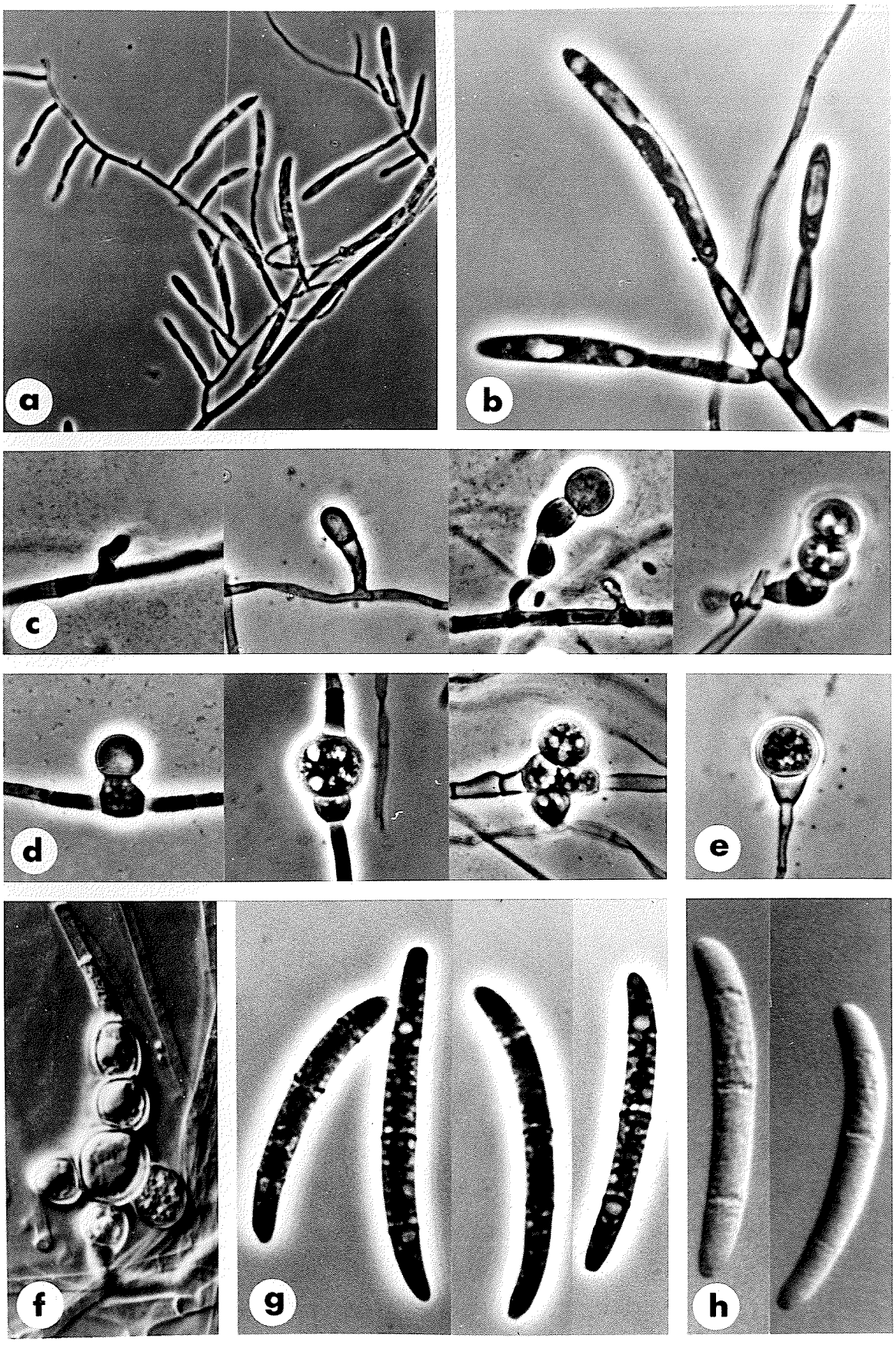

a
b
c
d
e
f
g
h

PLATE XIII

Dactylaria scaphoides Peach (Figures a - f)

Figure a. Proliferating conidiophore with swollen apex and several porospores (x 350)

Figure b. Proliferating conidiophores (x 350)

Figure c. Simple conidiophores (x 350)

Figure d. Sequential sympodial development showing development of denticle, spore initial, and sympodular branches with spores (x 1000)

Figure e. Sympodial conidiophore with several spore sites (x 650)

Figure f. Sympodular branch with porospore initial (x 1900)

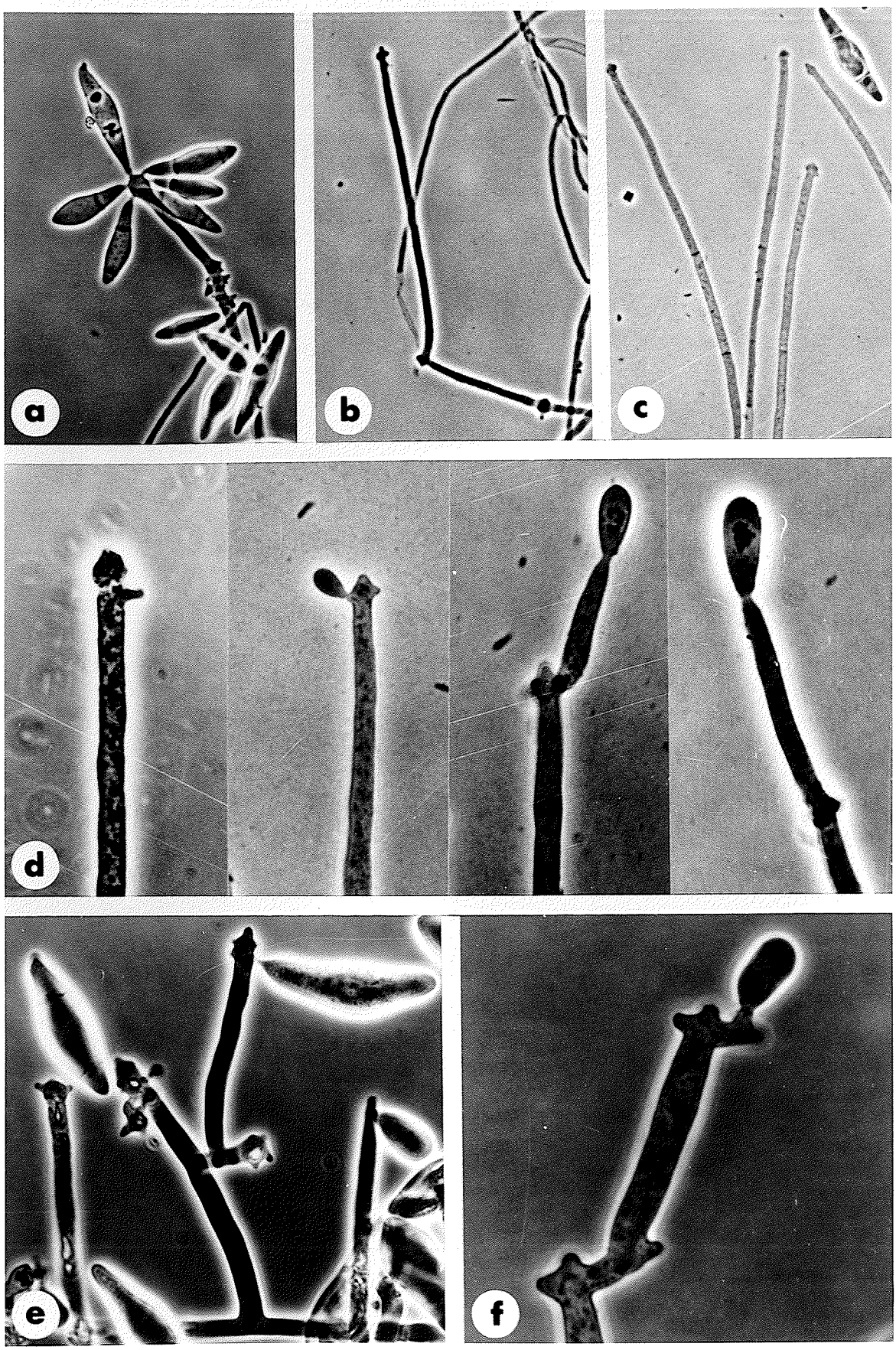

a
b
c
d
e
f

PLATE XIV

Dactylaria scaphoides Peach (Figure a)

Figure a. Porospores (x 950)

Doratomyces nanus (Ehrenb. ex Link) Morton & Smith (Figures b - g)

Figure b. Synnema (x 260)

Figure c. Synnema bearing annellophores and producing annellospores (x 850)

Figure d. Synnemal annellophores bearing mature annellospores (x 2000)

Figure e. Synnemal annellophores with immature spore showing basal attachment; annellations appear as dark ridges on the apex of the annellophore (arrow) (x 2000)

Figure f. Mycelial annellophores bearing annellospores (x 1000)

Figure g. Mycelial annellophores bearing annellospores; annellations appear as rings below the spore at the apex of the annellophore (arrow) (x 2500)

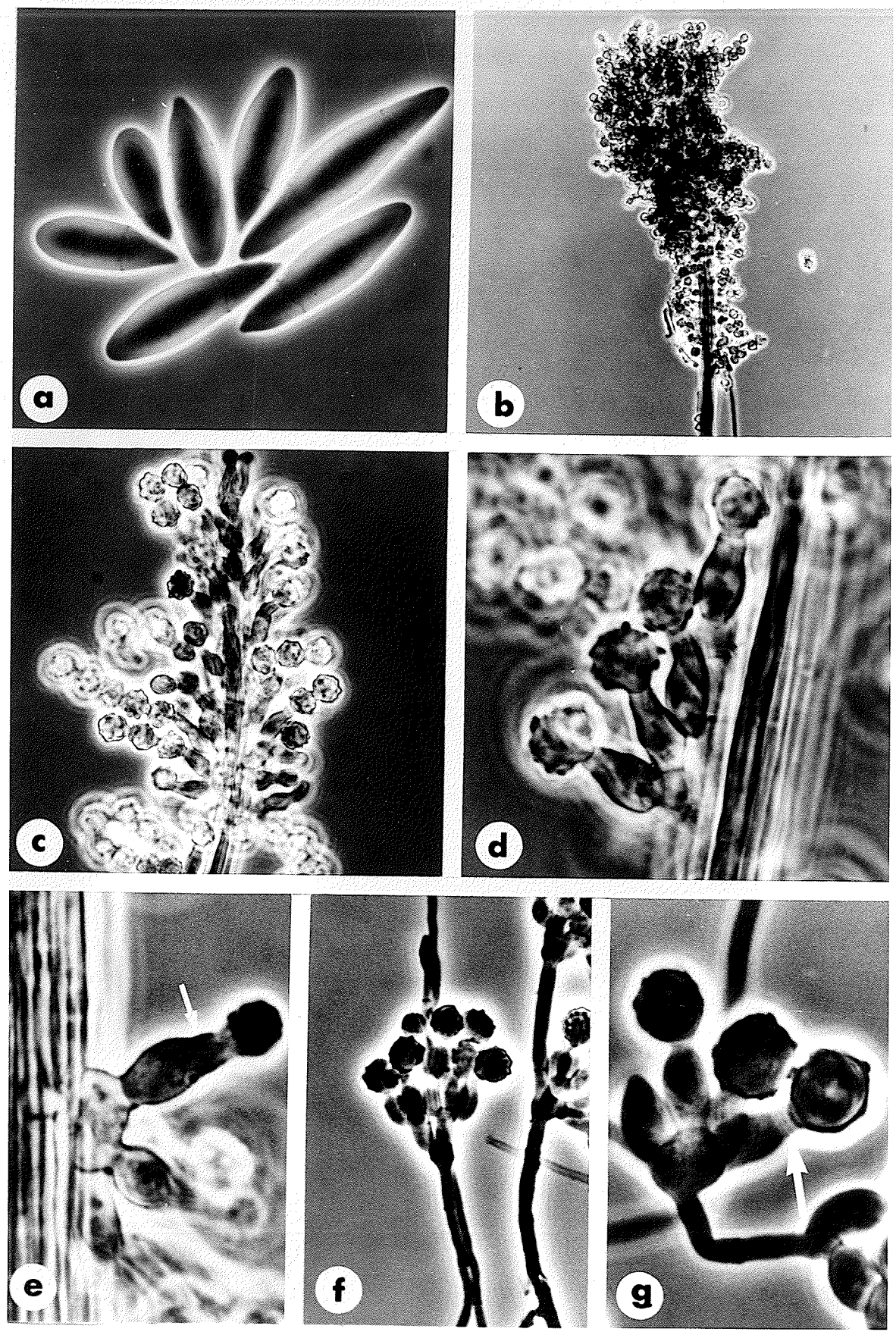

a
b
c
d
e
f
g

PLATE XV

Doratomyces nanus (Ehrenb. ex Link) Morton and Smith (Figures a and b)

Figure a. Branching mycelial annellophores bearing mature annellospores (x 2500)

Figure b. Verrucose annellospores (x 2000)

Emericellopsis sp. (Figures c - j)

Figure c. Conidial state; phialides bearing phialospores (x 1000)

Figure d. Phialospores (x 2000)

Figure e. Cleistothecium (x 350)

Figure f. Cleistothecial wall - textura intricata (x 2000)

Figure g. Immature asci containing ascospores (x 2000)

Figure h. Mature asci containing ascospores (x 2000)

Figure i. Ascospores containing oil droplets (x 2500)

Figure j. Ascospores showing ornamentation consisting of a modified gelatinous sheath (x 2500)

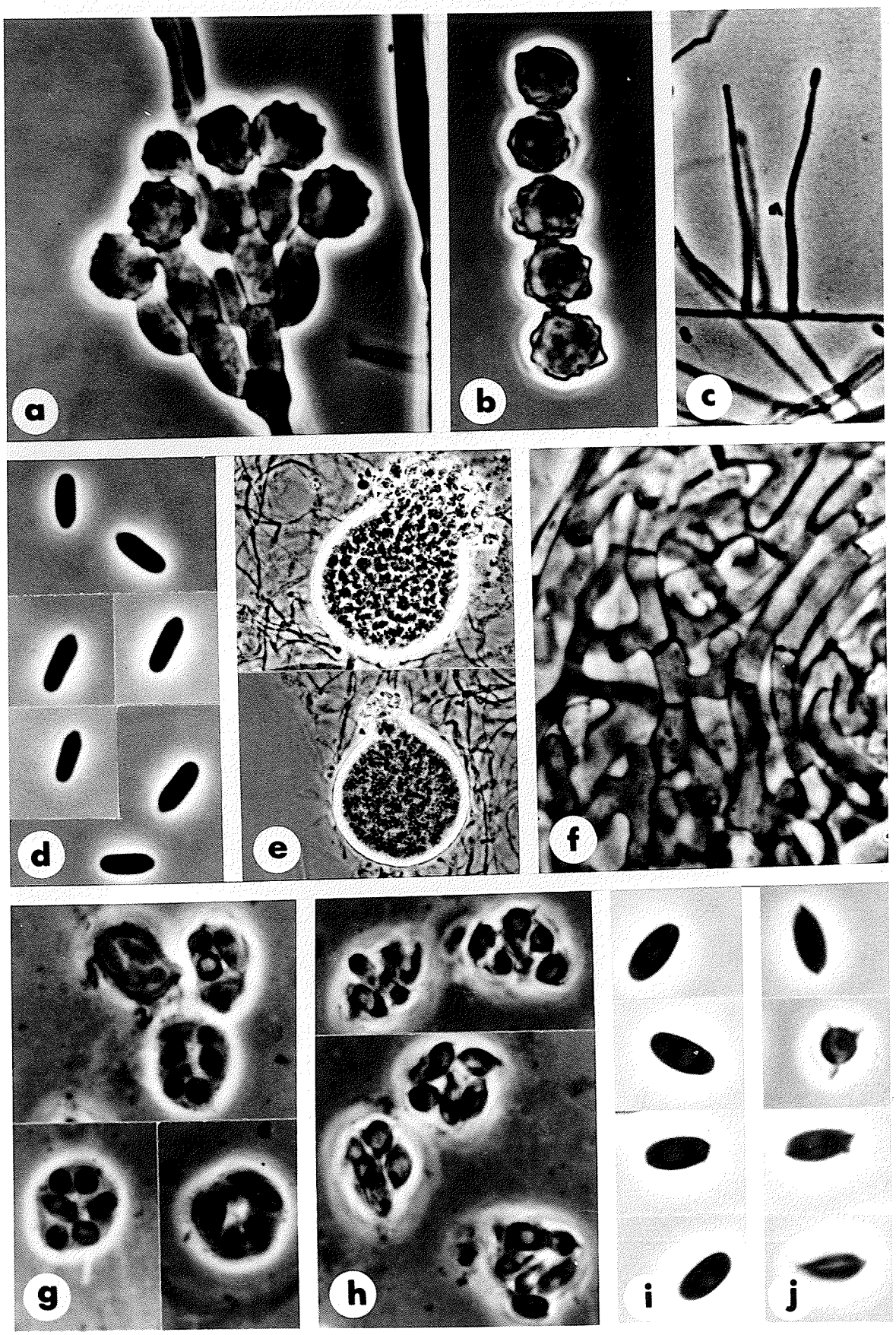

a
b
c
d
e
f
g
h
i
j

PLATE XVI

Gliocladium catenulatum Gilman & Abbott (Figures a - d)

Figure a. Habit - showing branching patterns (x 350)

Figure b. Verticillate branching (x 1000)

Figure c. Penicillate branching (x 1000)

Figure d. Phialospores (x 2000)

Gliocladium roseum Bain. (Figures e - h)

Figure e. Habit - showing branching patterns (x 270)

Figure f. Penicillate branching (x 1000)

Figure g. Verticillate branching (x 1000)

Figure h. Phialospores (x 2000)

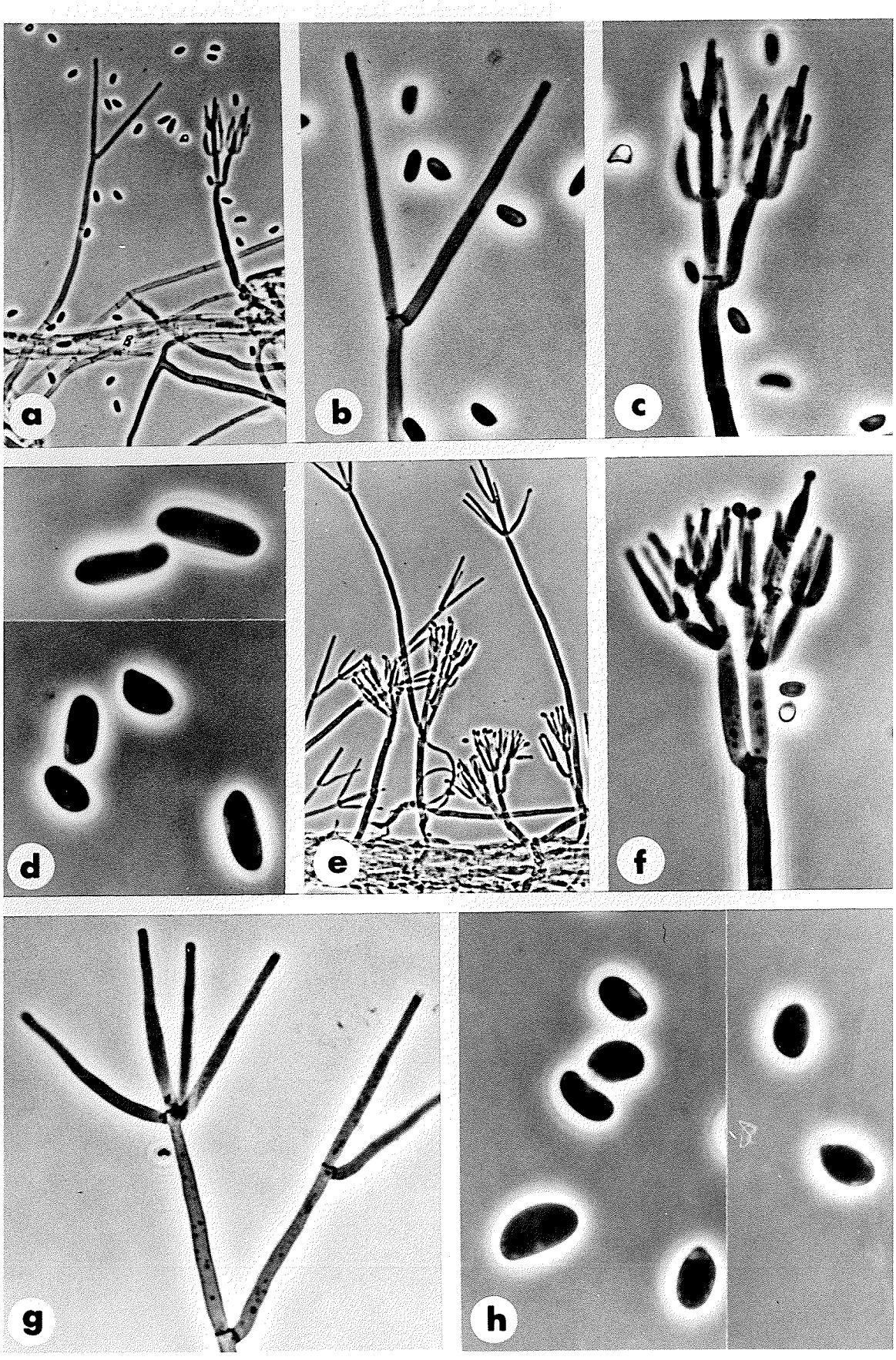

a
b
c
d
e
f
g
h

PLATE XVII

Hormiactus alba Preuss (Figures a and b)

Figure a. Habit (x 350)

Figure b. Adhering blastospores and connecting isthmus (x 1000)

Kernia pachypleura Malloch & Cain (Figures c - g)

Figure c. Conidial state - habit (x 1000)

Figure d. Conidial state - annellophores bearing annellospores; annellations appear as a roughened band(s) below the annellospores (arrow) (x 2000)

Figure e. Annellospores (x 2000)

Figure f. Perithecial wall - textura angularis (x 1000)

Figure g. Ascospores (x 2000)

Mortierella alpina Peyronel (Figure h)

Figure h. Sporangiophore bearing a sporangium (x 350)

a
b
c
d
e
f
g
h

PLATE XVIII

Mortierella alpina Peyronel (Figures a - c)

Figure a. Sporangiophore tip (x 1000)

Figure b. Sporangiophore foot cell (x 1000)

Figure c. Sporangiospores (x 2000)

Mortierella hyalina (Harz) Gams (Figures d - l)

Figure d. Habit - branched sporangiophores with sporangia (x 310)

Figure e. Branched sporangiophores with immature sporangia (x 400)

Figure f - i. Sporangium with maturing sporangiospores

Figure f. Sporangium containing cytoplasmic mass (wall has ruptured in mounting) (x 1000)

Figure g. Enlarged sporangium containing cleaving cytoplasmic mass (x 1000)

Figure h. Sporangium containing immature sporangiospores (x 1000)

Figure i. Sporangium containing mature sporangiospores (x 1000)

Figure j. Sporangiospores (x 1000)

Figure k. Sporangiophore tip and remnant sporangial wall (x 1000)

Figure l. Intercalary chlamydospores (x 500)

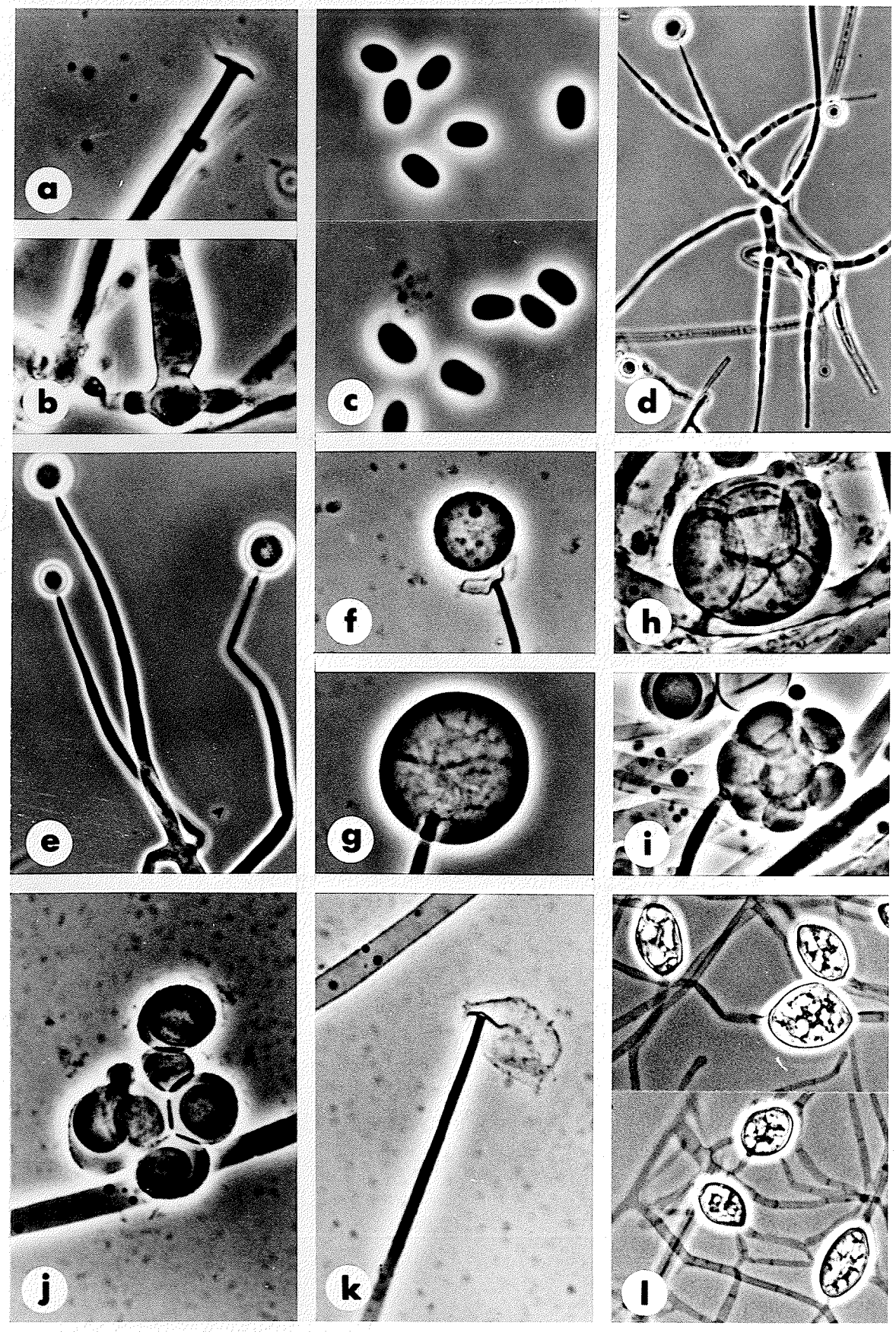

a
b
c
d
e
f
g
h
i
j
k
l

PLATE XIX

Mariannaea elegans (Corda) Samson, var. *elegans* Samson (Figures a - d)

Figure a. Habit (x 350)

Figure b. Conidiophore with whorls of phialides bearing phialospores (x 1000)

Figure c. Phialide branch bearing phialospore (x 2000)

Figure d. Phialospores (x 2000)

Paecilomyces farinosus (Holm ex S. F. Gray) Brown & Smith (Figures e - h)

Figure e. Habit (x 400)

Figure f. Vegetative hyphae bearing whorls of phialides producing phialospores (x 1000)

Figure g. Phialides with single or chained phialospores (x 2000)

Figure h. Phialospores - single and adhering (x 2000)

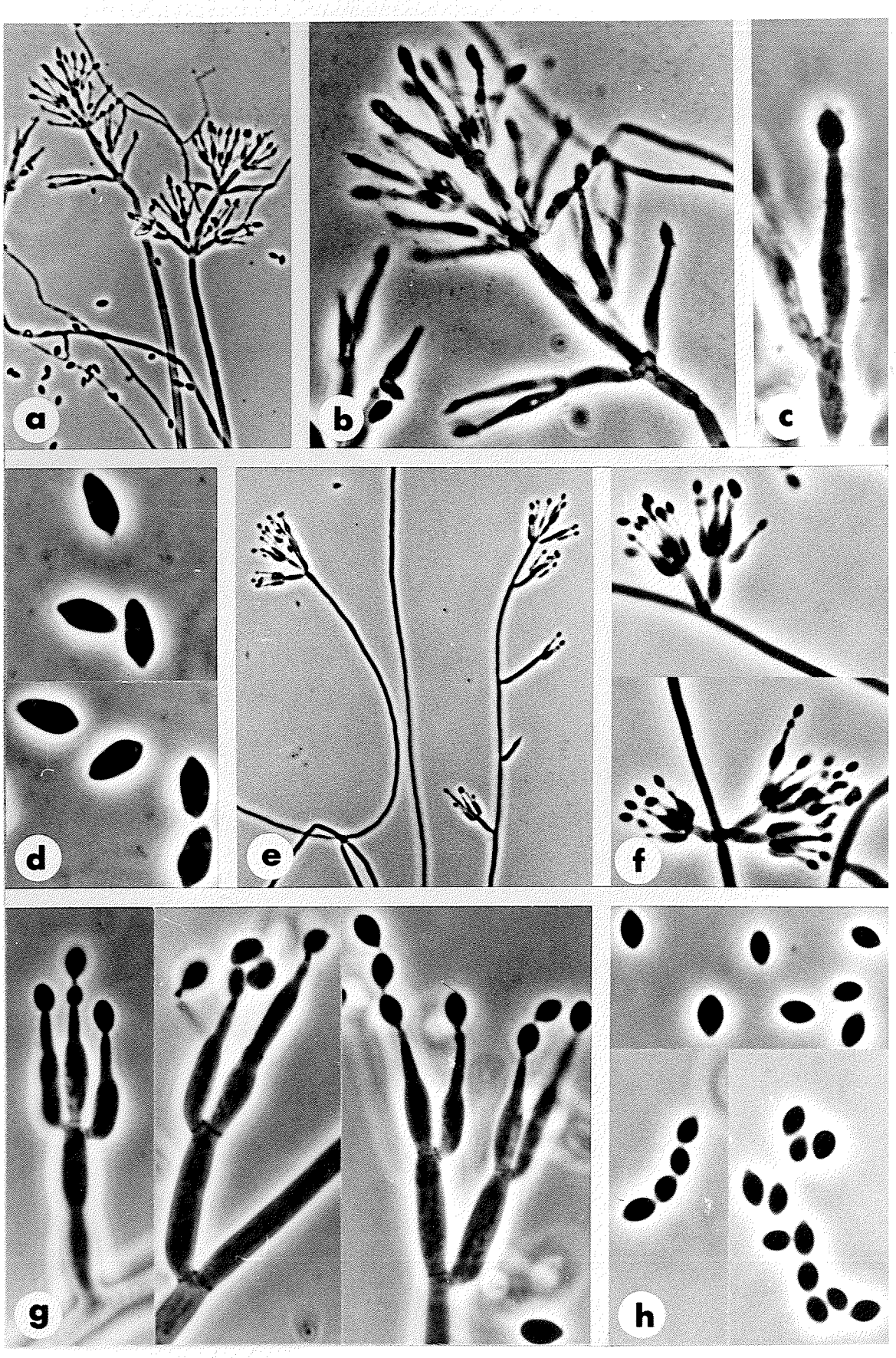

a
b
c
d
e
f
g
h

PLATE XX

Paecilomyces marquandii (Massee) Hughes (Figures a - e)

Figure a. Habit (x 350)

Figure b. Conidiophore with penicillate branches bearing phialides producing phialospores (x 1000)

Figure c. Penicillate branches bearing phialides producing phialospores; collarette shows as dark region on neck of phialides (arrow) (x 2000)

Figure d. Phialospores - adhering and single (x 2000)

Figure e. Terminal chlamydospore (x 1000)

Penicillium cf. *canescens* Sopp. (Figures f and g)

Figure f. Slightly roughened conidiophores bearing phialides producing phialospores (x 1000)

Figure g. Phialides producing phialospores (x 2000)

Penicillium cf. *citrinum* Thom (Figures h - j)

Figure h. Conidiophore bearing phialides producing phialospores (x 350)

Figure i. Phialides producing phialospores (x 2000)

Figure j. Tuberculate conidia (x 2000)

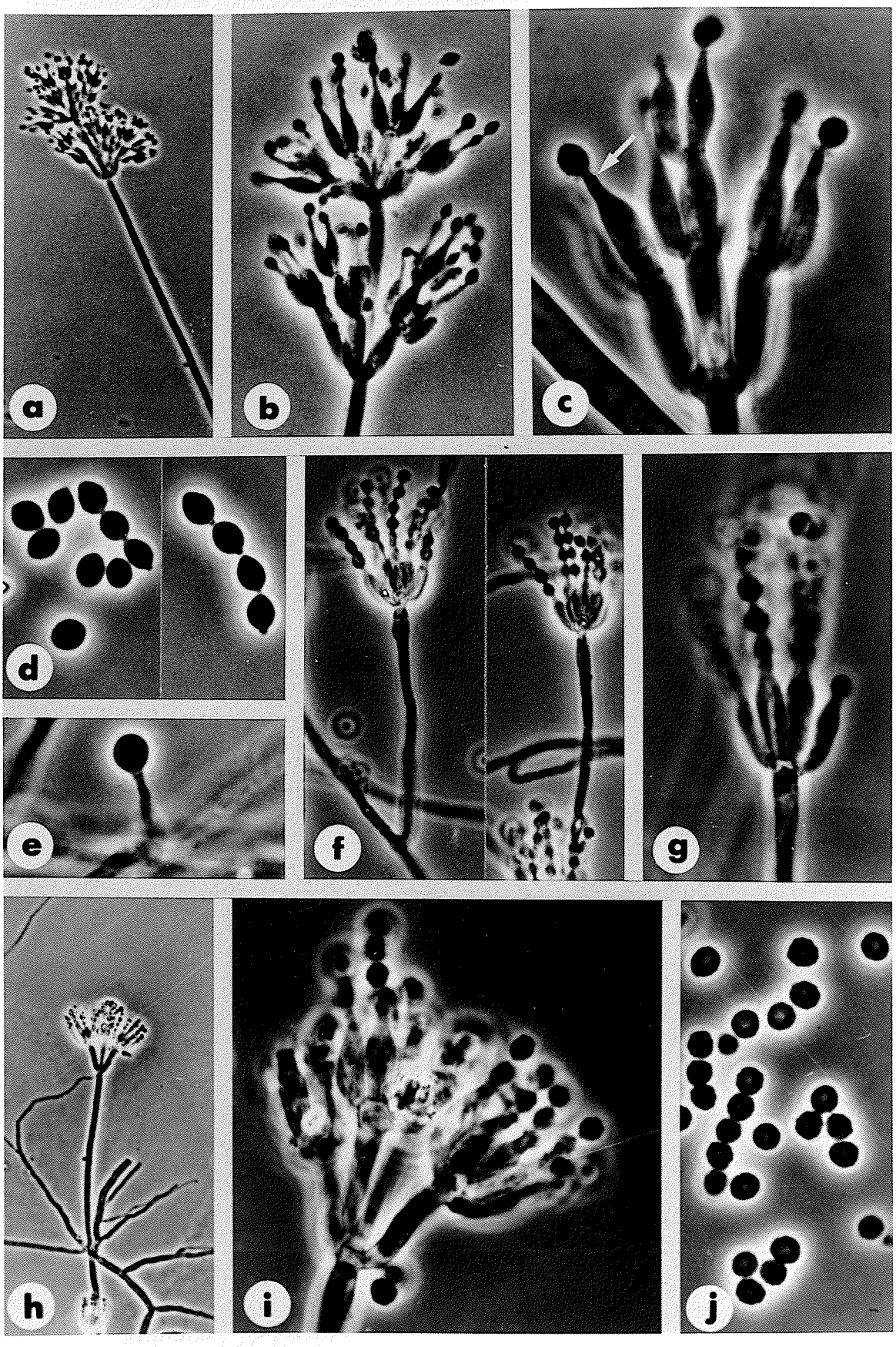

a
b
c
d
e
f
g
h
i
j

PLATE XXI

Penicillium cf. damascenum Bagdadi (Figures a - c)

Figure a. Conidiophore bearing phialides producing phialospores (x 350)

Figure b. Roughened conidiophore bearing phialides producing phialospores (x 1000)

Figure c. Phialides and phialospores (x 1900)

Penicillium cf. jenseni Zaleski (Figures d - f)

Figure d. Conidiophores bearing phialides producing phialospores (x 350)

Figure e. Roughened conidiophore bearing phialides producing phialospores (x 1000)

Figure f. Phialides and phialospores (x 1900)

Phialophora fastigiata (Lagerb. & Melin) Conant (Figures g and h)

Figure g. Phialides; prominent collarette appears as a cup-like frill at the tip of the phialide(s) (arrow) (x 2000)

Figure h. Phialospores (x 2000)

Phialophora malorum (Kidd & Beaum.) McColloch (Figure i)

Figure i. Phialides producing phialospores (x 2000)

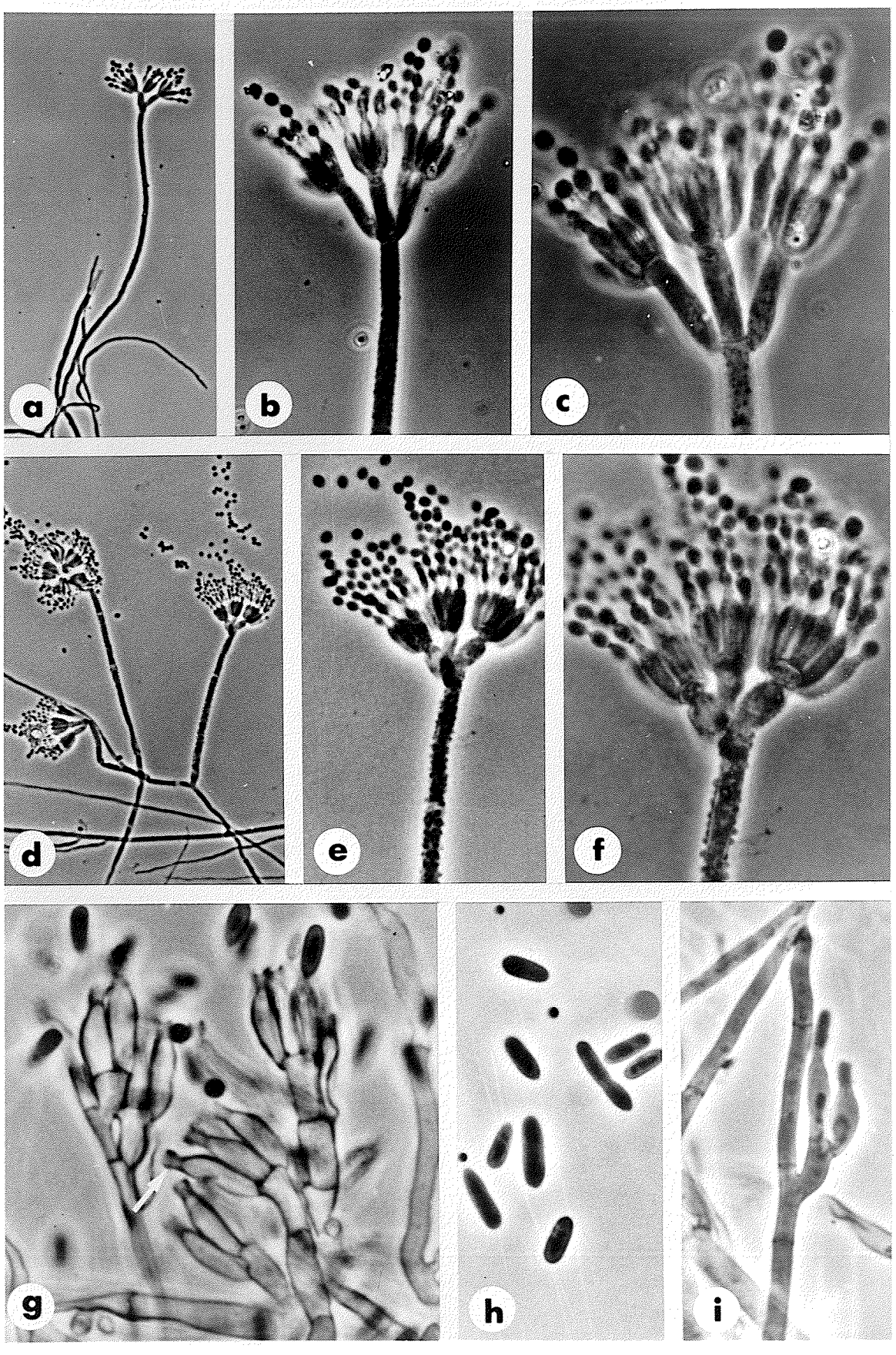

a
b
c
d
e
f
g
h
i

PLATE XXII

Phialophora malorum (Kidd & Beaum) McColloch (Figures a and b)

Figure a. Phialides (x 2000)

Figure b. Phialospores (x 2000)

Phialophora sp. nov. (Figures c - h)

Figure c. Phialides producing cylindric endogenous first-formed (primary) spores; ruptured wall produces the prominent collarettes (x 2000)

Figure d. Phialide with gloeoid phialospore mass (x 2000)

Figure e. Phialide with prominent collarette (x 2000)

Figure f. Phialides with secondary phialospores (x 2000)

Figure g. Cylindric primary endogenous spores (x 2000)

Figure h. Globose secondary phialospores (x 2000)

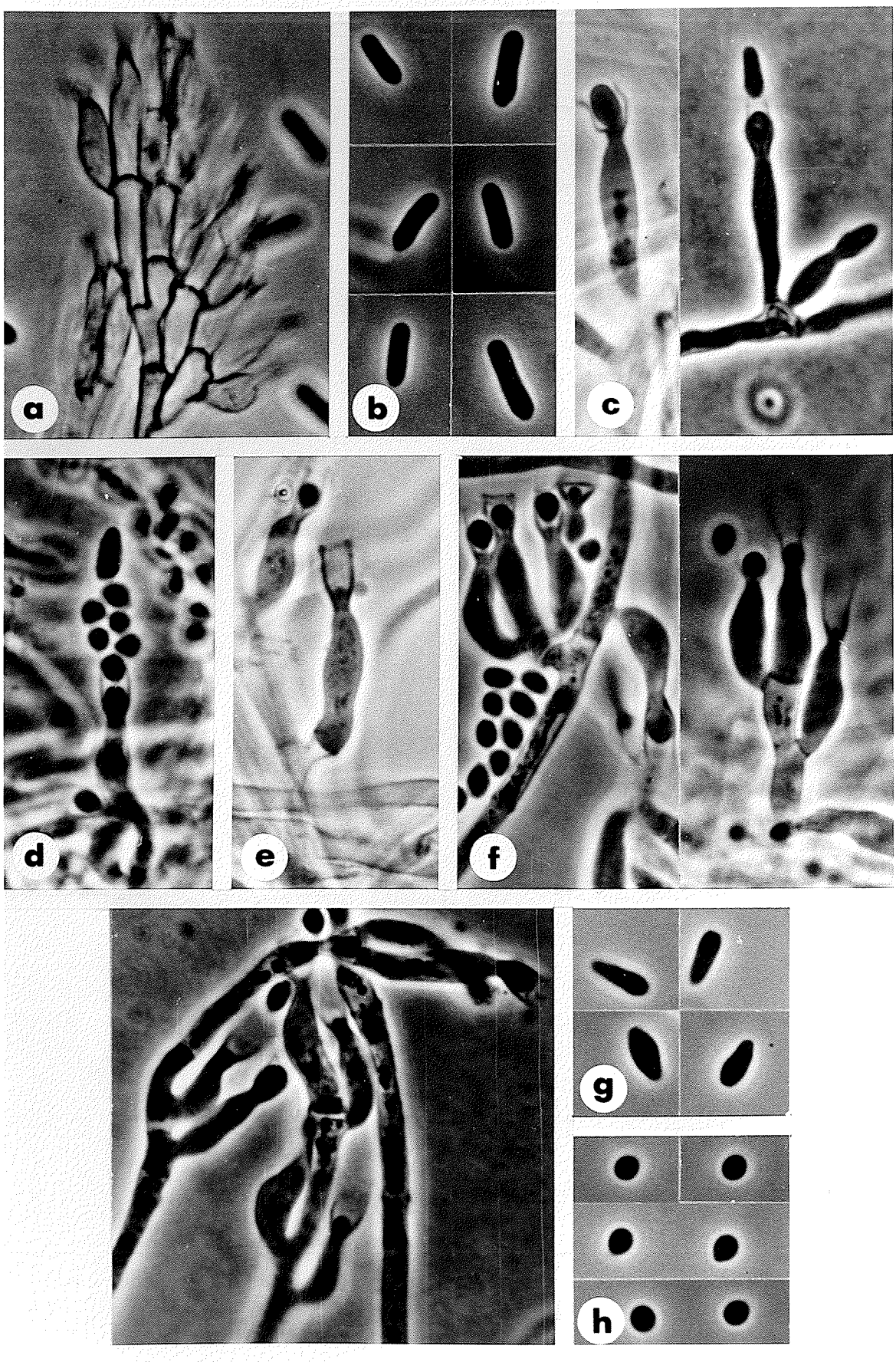

a
b
c
d
e
f
g
h

PLATE XXIII

Peziza ostracoderma Korf(conidial state)(Figures a - d)

Figure a. Branching conidiophore (immature) (x 120)

Figure b. Conidiophore with branching ampullae and mature blastospores (x 250)

Figure c. Tip of an ampulla showing connections between ampullae and blastospores (x 2000)

Figure d. Blastospores (x 1000)

Rhinocladiella cf. *anceps* (Sacc. & Ellis) Hughes (Figures e - i)

Figure e. Conidiophores with denticulate sporogenous tips (x 700)

Figure f. Proliferating conidiophore; old sporogenous site appears below tip (arrow) (x 1000)

Figure g. Proliferating conidiophore tip; new growth (arrow) extruding beyond previous sporogenous site (x 2000)

Figure h. Conidiophore tip with immature blastospore (x 2000)

Figure i. Blastospores (x 2000)

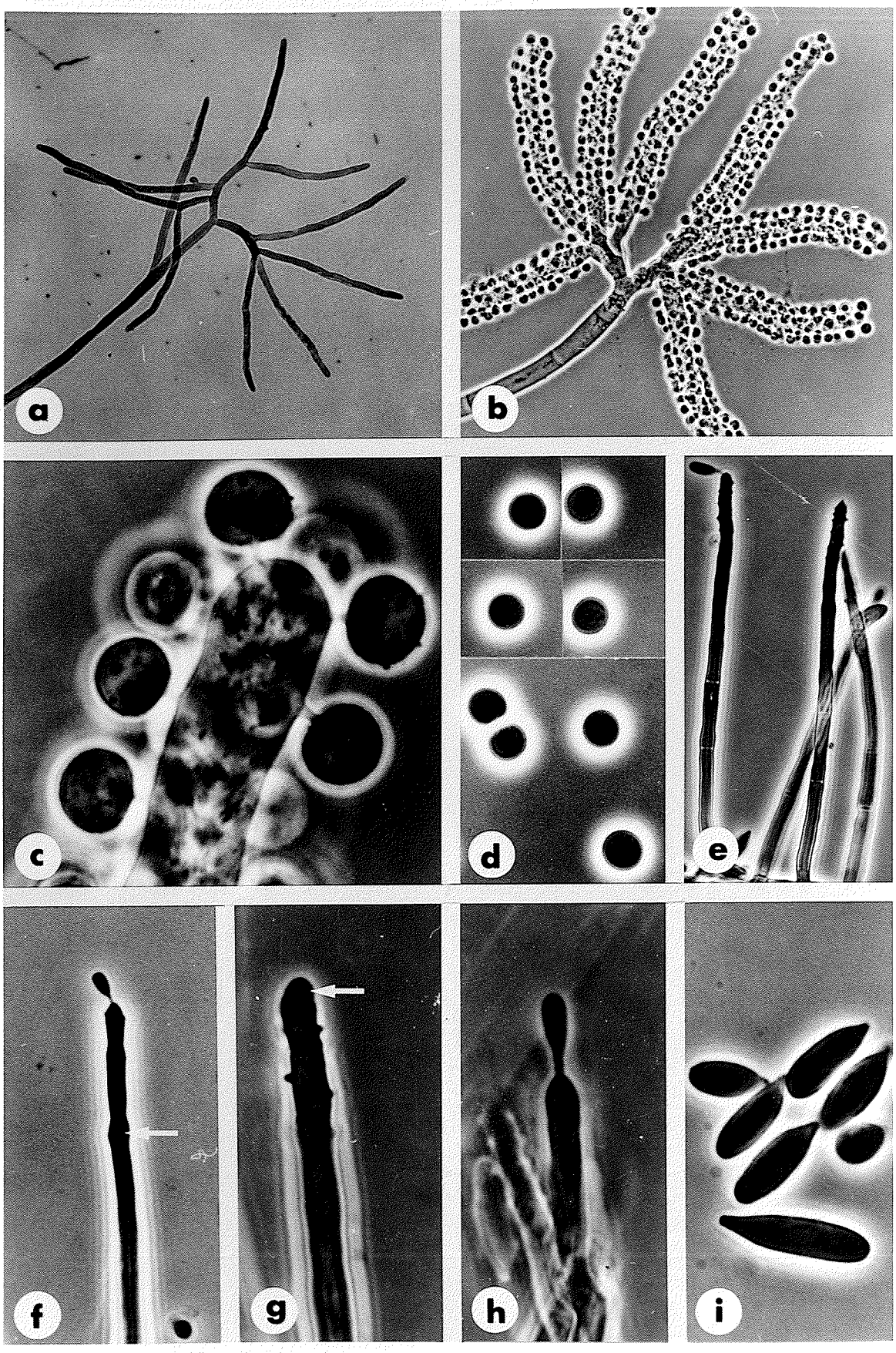

a
b
c
d
e
f
g
h
i

PLATE XXIV

Rhinocladiella mansonii (Castell.) Schol-Schwarz (Figures a - d)

Figure a. Vegetative hyphae bearing branching chains of Cladosporium-like blastospores (x 1000)

Figure b. Sporogenous cells: Cladosporium-like (upper left), pleurogenous muzzle-like protuberances (upper right) and denticulate type (lower) (x 1000)

Figure c. Phialides similar to those of Phialophora; flared collarette appears at tip (arrow) (x 2000)

Figure d. Conidia (x 2000)

Sporothrix sp.

Figure e. Habit - sporogenous cells bearing sympodulospores (x 1000)

Sporotrichum epigaeum Brun. var. terrestre Daszewska (Figures f - h)

Figure f. Habit - sporogenous cells bearing aleuriospores (x 850)

Figure g. Branched sporogenous cells bearing aleuriospores; spores attached by narrow subtending sporogenous hyphae (arrow) (x 2000)

Figure h. Aleuriospores (x 2000)

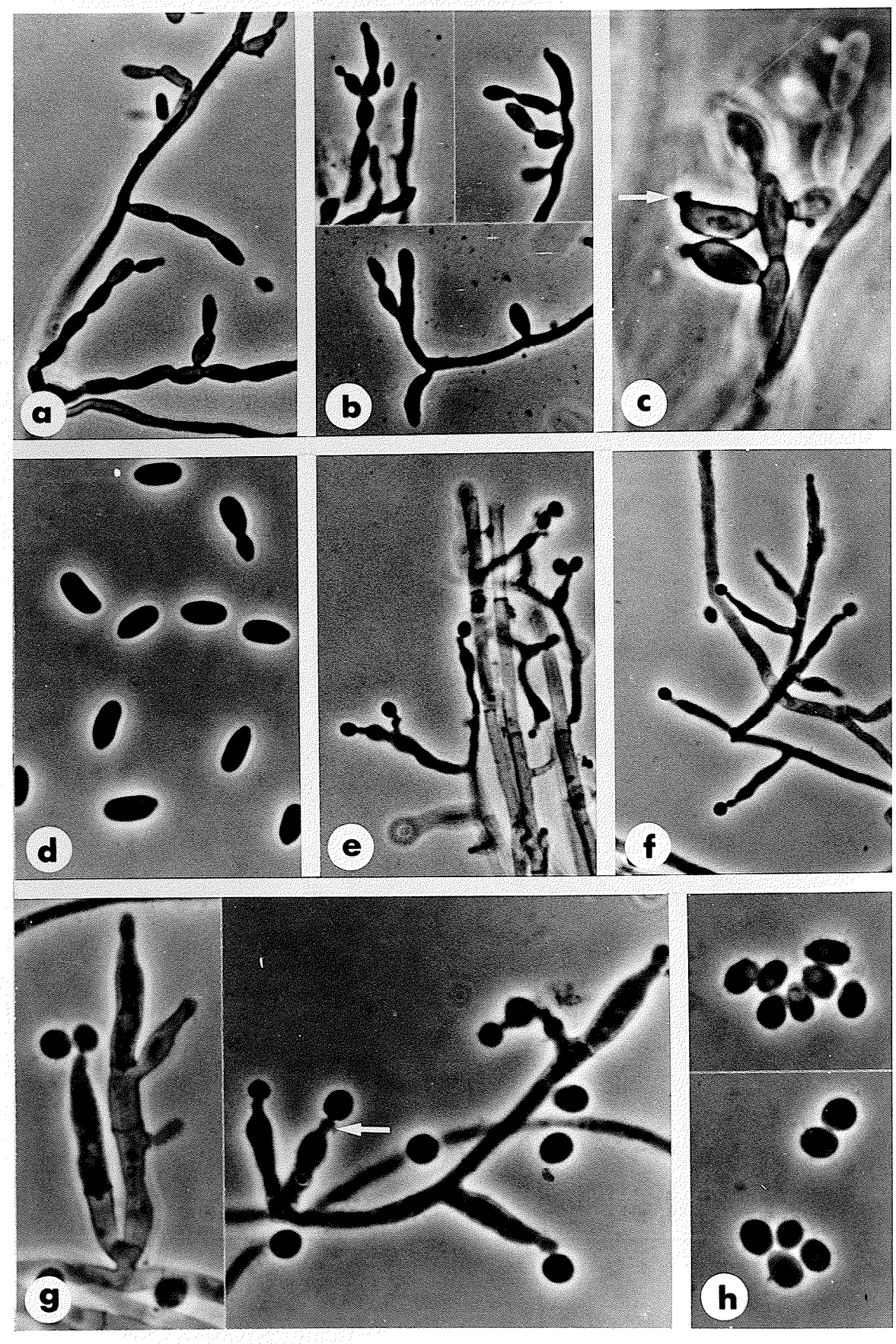

a
b
c
d
e
f
g
h

PLATE XXV

Stachybotrys cf. atra Corda (Figures a - d)

Figure a. Habit (x 350)

Figure b. Conidiophores with phialides and gloeoid masses of phialospores (x 650)

Figure c. Verrucose conidiophores with phialides; several phialides producing new phialospores (x 2000)

Figure d. Phialospores (x 2000)

Taxonomic genus #1 (Figures e - g)

Figure e. Habit (x 800)

Figure f. Flask-shaped phialides with eccentrically positioned phialospores (x 2500)

Figure g. Phialides producing phialospores (x 2500)

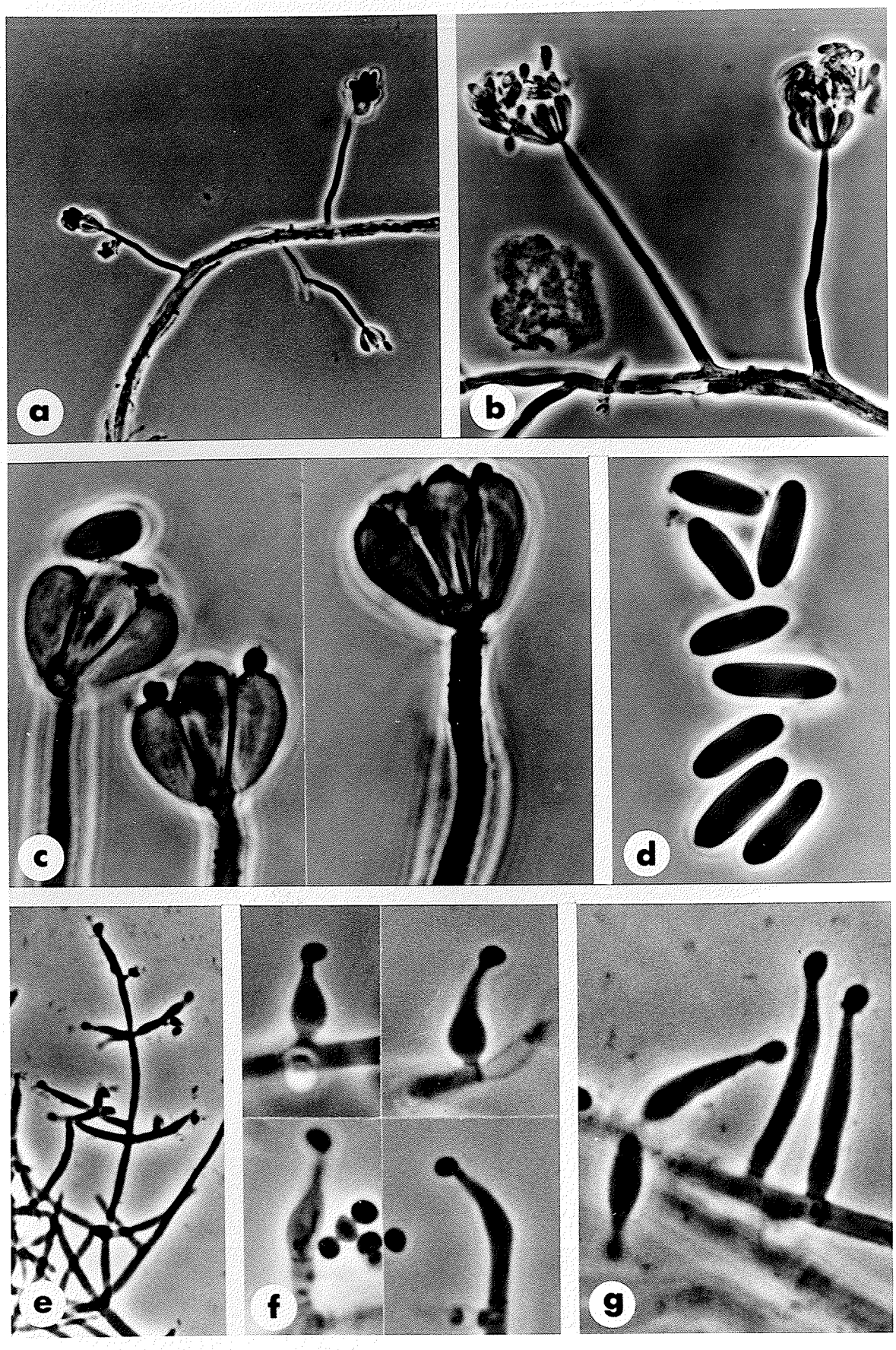

a
b
c
d
e
f
g

PLATE XXVI

Taxonomic genus #1 (Figures a - c)

Figure a. Verticillium-like phialides producing phialospores (x 2500)

Figure b. Elongated terminal phialide and a phialospore (x 2500)

Figure c. Phialospores (x 2500)

Trichosporon sp. (Figures d and e)

Figure d. Pseudomycelium (arthrospores) (x 1000)

Figure e. Blastospores (x 1000)

Trichuris spiralis Hasselbring (Figures f - i)

Figure f. Synnema bearing setiform branches and annellospores (x 250)

Figure g. Base of synnema (x 250)

Figure h. Synnemal annellophores producing annellospores laterally on the synnema (x 2000)

Figure i. Synnemal annellophores producing annellospores terminally on the synnema (x 2000)

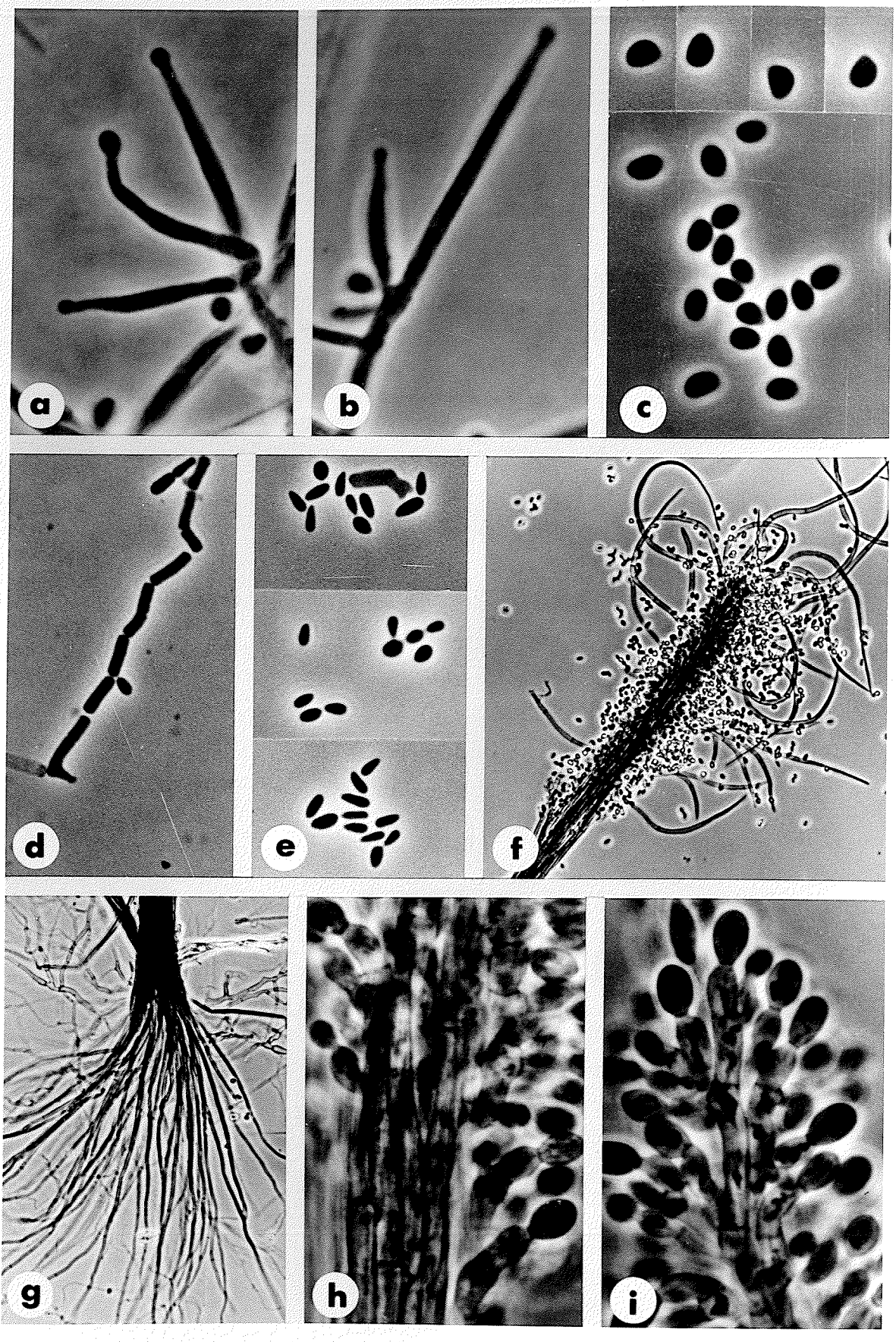

a
b
c
d
e
f
g
h
i

PLATE XXVII

Trichurus spiralis Hasselbring (Figures a and b)

Figure a. Synnemal annellophores; annellations appear as a thickening on the tip of the annellophores (arrow); an immature setiform branch is present in the upper area of the photograph (x 2500)

Figure b. Annellospores (x 2000)

Ulocladium atrum Preuss (Figures c - g)

Figure c. Habit (x 350)

Figure d. Acropetalous sympodular conidiophores bearing mature and developing porospores (x 850)

Figure e. Cicatrized sympodial conidiophore tip bearing a mature and a developing porospore (x 2200)

Figure f. Porospores (x 850)

Figure g. Porospore showing verrucose roughenings (x 2000)

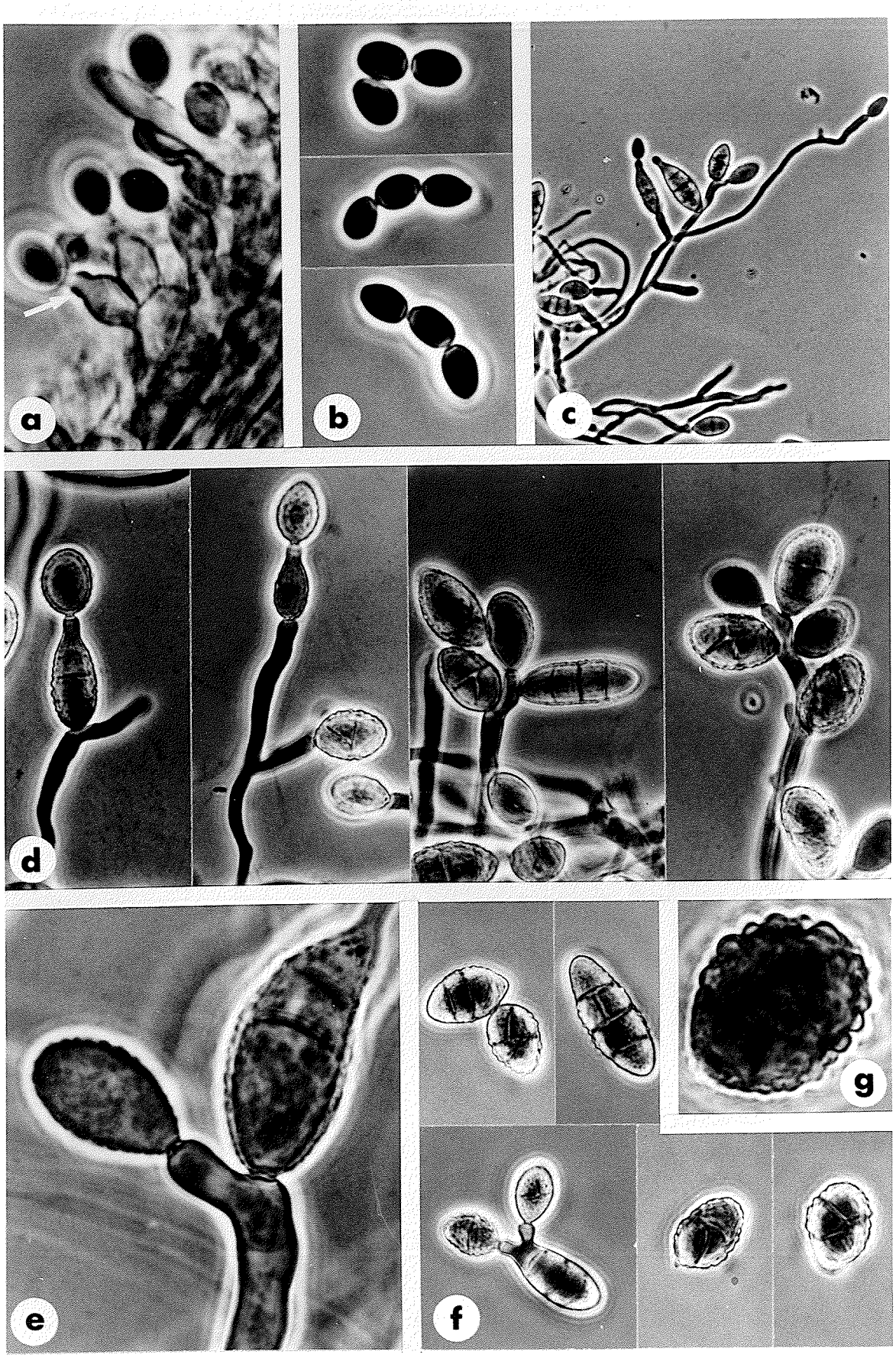

a
b
c
d
e
f
g

PLATE XXVIII

Verticillium tax. sp. 2 (Figures a - c)

Figure a. Phialides producing phialospores (x 850)

Figure b. Phialospores (x 2000)

Figure c. Terminal chlamydospores forming chains (x 1900)

Verticillium lamellicola (F.E.V. Smith) W. Gams (Figures d and e)

Figure d. Whorled phialides (x 850)

Figure e. Phialospores (x 2000)

Verticillium lecanii (Zimm.) Viégas (Figures f and g)

Figure f. Whorled phialides (x 850)

Figure g. Phialospores (x 2000)

Verticillium tax. sp. 1 (Figure h)

Figure h. Branched phialides producing phialospores (x 850)

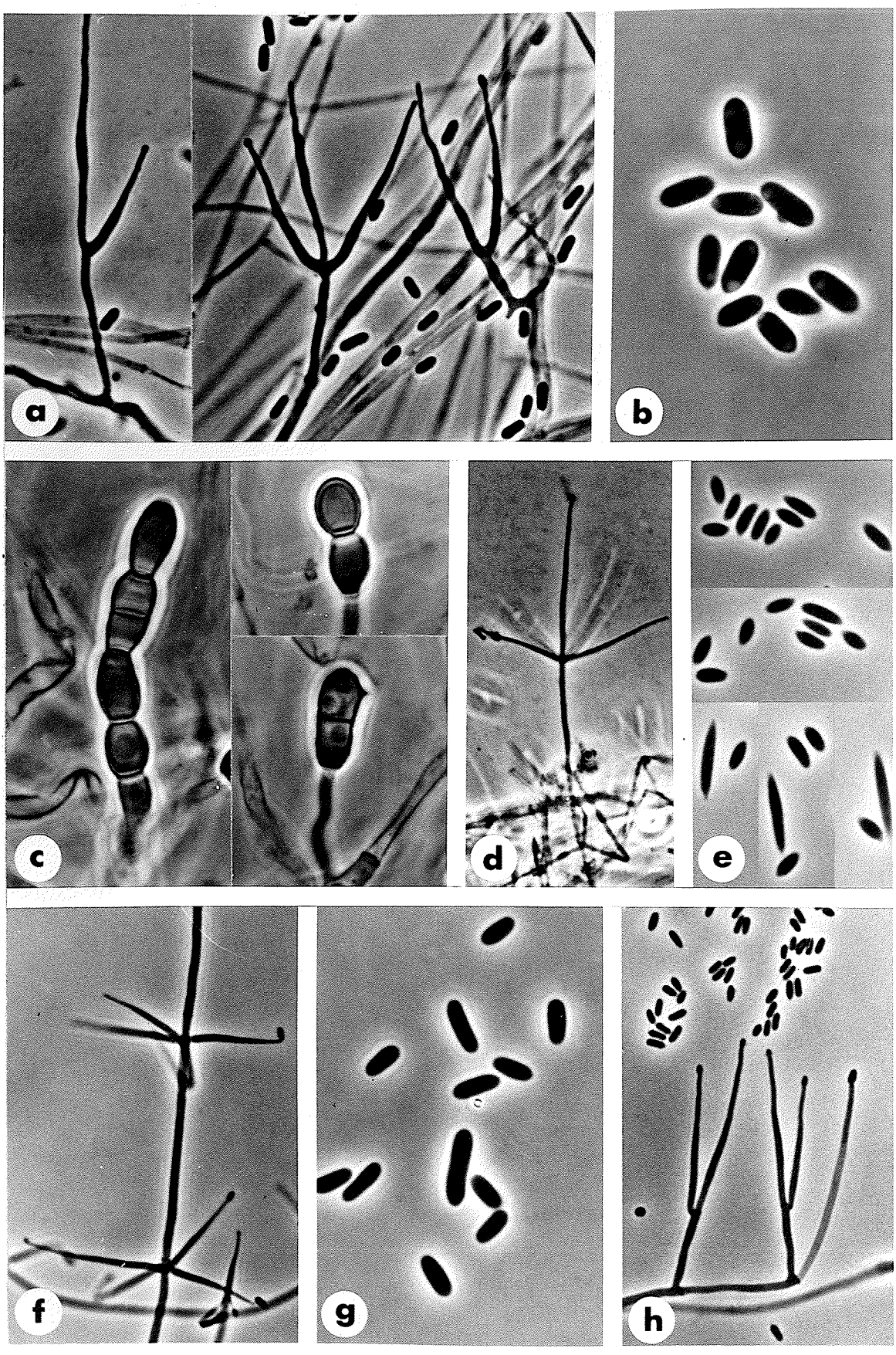

a
b
c
d
e
f
g
h

PLATE XXIX

Verticillium tax. sp. 1 (Figures a and b)

Figure a. Branched phialides producing a gloeoid mass of phialospores (x 850)

Figure b. Phialospores (x 2000)

Verticillium tenerum (Nees ex Pers.) Link (Figures c and d)

Figure c. Conidiophores with whorls of phialides producing phialospores (x 630)

Figure d. Phialospores (x 2000)

Volutella ciliata (Alb. & Schw.) Fr. (Figures e - g)

Figure e. Setose sporodochium (x 250)

Figure f. Immature sporodochium with phialides producing phialospores (x 850)

Figure g. Single, dichotomous and verticillately branched phialides; collarette appears as dark region on flanks of phialide neck (arrow) (x 2000)

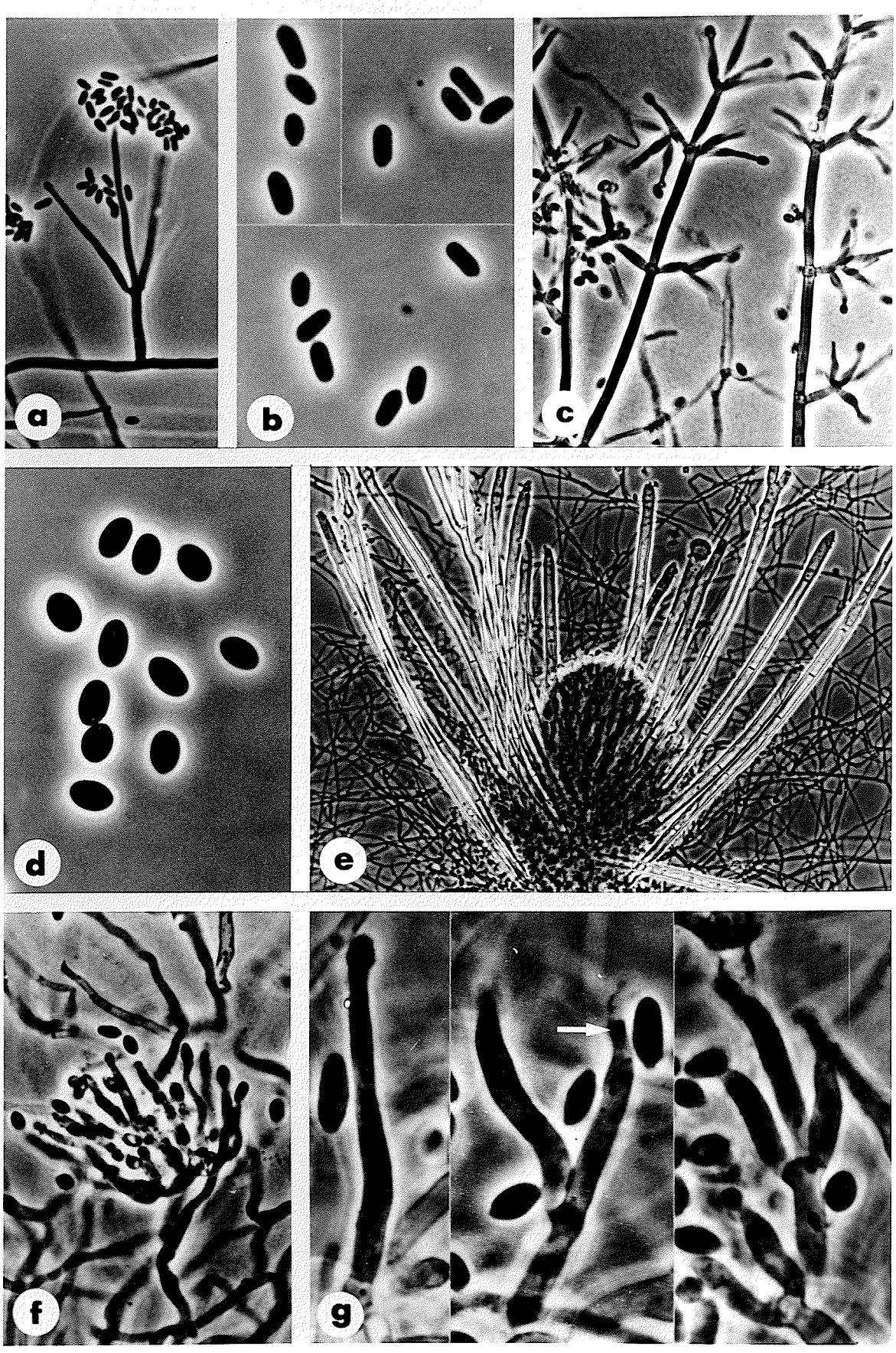

a
b
c
d
e
f
g

PLATE XXX

Volutella ciliata (Alb. & Schw.) Fr. (Figure a)

Figure a. Phialospores (x 850)

Volutella sp. (Figures b - d)

Figure b. Habit - showing several sporodochial masses (x 850)

Figure c. Phialospores (x 2000)

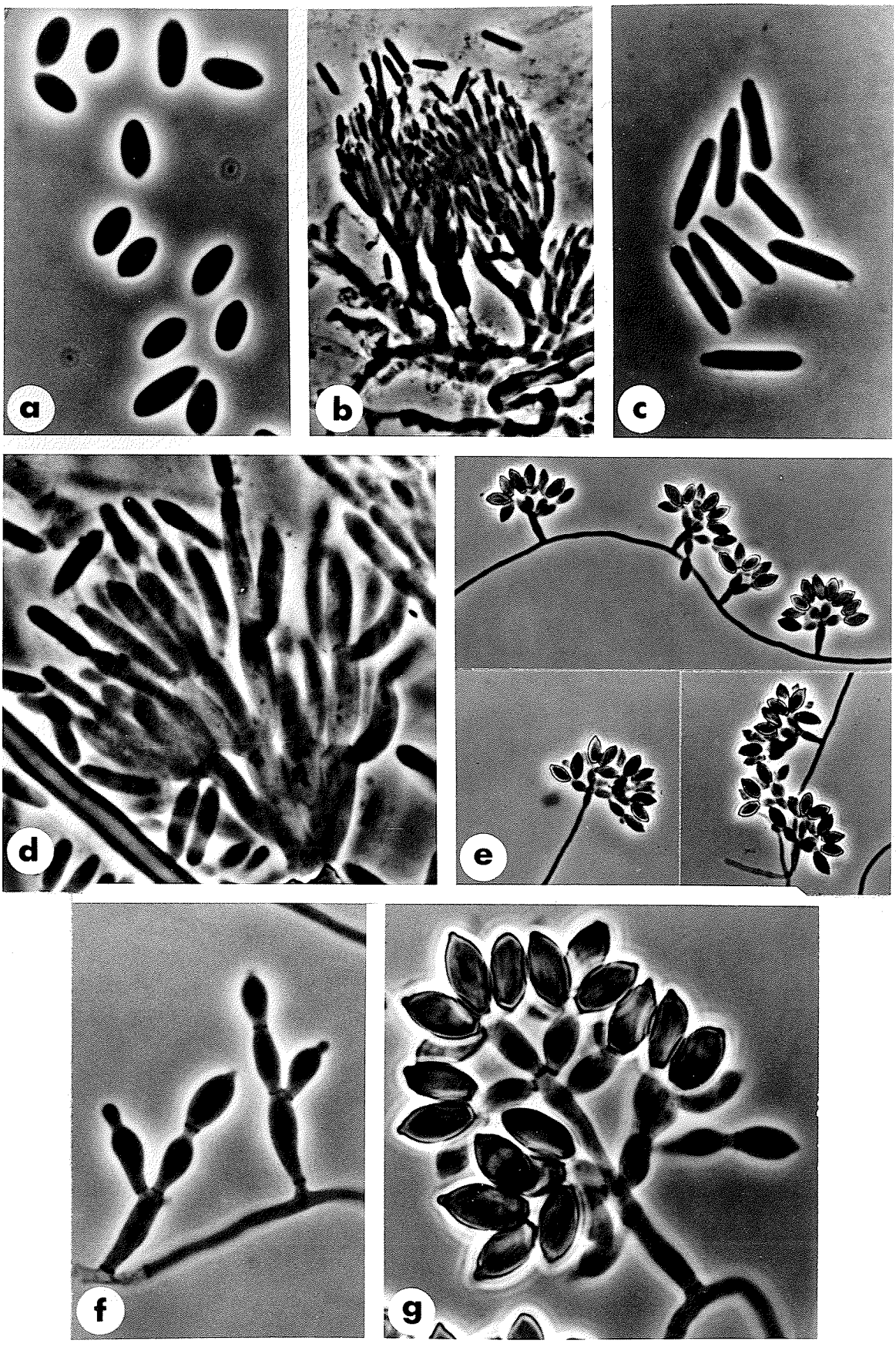
Figure d. Phialides producing phialospores (x 2000)

Wardomyces anomalus Brooks & Hansf. (Figures e - g)

Figure e. Habit (x 650)

Figure f. Branched polyblastic conidiogenous cells producing blastoconidia (x 2000)

Figure g. Penicillately arranged polyblastic conidiogenous cells bearing mature and immature blastoconidia (x 2000)


a
b
c
d
e
f
g

RESULTS:

FUNGAL DISTRIBUTION BY SITE

AND

CULTURAL STUDIES

I. Composition of Fungal Species and Genera

A combined total of 109 species from 43 genera of fungi, including representatives of the Phycomycetes*, Sphaeropsidales and Mycelia Sterilia, were isolated from beach ridge and marsh soils (Appendix E, Table XL). Eighty-one species from 31 genera were isolated from the 0-30 cm profile of beach ridge soil. Marsh soil isolates from the 0-10 cm profile numbered 68 species from 37 genera. A number of species were isolated from either marsh or beach ridge soils. Thirty-nine of 81 beach ridge species (36% of all species) and 28 of 68 marsh species (26% of all species) occurred only at the isolation sites. The remaining 42 species (38% of all fungal species isolated) were common to both sites.

Of the 43 genera isolated, the genus showing the greatest species diversity was Penicillium (19), followed by Fusarium (11), Verticillium (7), Acremonium (6), Cylindrocarpon (6), and Trichoderma (4). Five genera were represented by three different species, six genera by two species, and 26 by only one each.

The predominent genera of the two sites hardly vary with respect to species diversity. The species diversity of genera with three or more species (expressed as the percent of total species) are as follows:

Beach Ridge Soil			Marsh Soil		
Penicillium	17/19	89%	Penicillium	10/19	53%
Fusarium	10/11	91%	Verticillium	6/7	86%
Verticillium	5/7	71%	Fusarium	5/11	45%
Acremonium	4/6	67%	Acremonium	4/6	67%
Cylindrocarpon	4/6	67%	Cylindrocarpon	3/6	50%

* The term Phycomycetes used herein indicates unidentified members of the classes Zygomycetes and Oomycetes.

Beach Ridge Soil			Marsh Soil		
Trichoderma	3/4	75%	Trichoderma	3/4	75%
Mortierella	3/3	100%	Chrysosporium	3/3	100%
Paecilomyces	3/3	100%	Paecilomyces	3/3	100%
Pyrenochaeta	3/3	100%	Phialophora	3/3	100%

The similarity of these two sites with regard to species diversity within predominent genera is striking. Seven of the nine genera are the same for both sites and (with the exception of Verticillium and Fusarium which are reversed) the order of the first six genera is identical for both sites. The percent of total species is the same for many genera but major differences exist for Penicillium, Verticillium and Fusarium.

2. Propagule Numbers

The fungal propagule numbers for all species in each soil profile for both beach ridge and marsh were calculated (Appendix F) for all culture conditions (all media at all temperatures). This data is contained in Appendix E, Tables I-XV and Tables XVI-XXXI for beach ridge and marsh soil respectively. The propagule data in these tables were produced using the maximum number of colonies isolated, or maximum plate counts, from among all 16 culture conditions for each soil profile as a base value. It should be recognized that while considerable variation existed in the actual numbers of fungi isolated under these 16 conditions, use of the maximum values is a method of recording propagule values for what can be termed ideal cultural conditions. On the other hand, the use of numbers of fungi isolated instead of plate counts for generating propagule data yields reduced values. The latter was done because colony overgrowth problems and the quantity of plates to be counted made the usual plate-

count method too time consuming. Since the major function of the propagule data is for comparative purposes, it was felt that this method would not detract significantly from the validity of the study.

For comparative purposes regarding temperature and media effects on propagative numbers, Tables XXXV - XXXIX were prepared. As can be seen from Tables XXXV - XXXVII no data were collected from some cultural conditions. This was due to overgrowth of plates by spreading fungi such as the Zygomycetes. Where no data existed for a particular culture condition, average data have been substituted in the tables. This was done to give a more "balanced" value when averaging temperature or media data. The average values for propagative numbers using substituted average values have been termed "adjusted values" and appear along with unadjusted values in the tables.

(a) Propagule Numbers and Soil Profile

An examination of tables XXXII - XXXIV reveals considerable variation in the propagule numbers obtained for each of the culture conditions with each of the three beach ridge soil profiles. The 0-10 cm has a minimum value of 37,064 propagative units/g dry wt. soil (LCV at 20° C) and a maximum value of 77,164 propagative units/g dry wt. soil (PDA at 15° C). Minimum and maximum values for propagative units per gram dry weight of soil for the 10-20 cm and 20-30 cm profiles are 52,800 (LCV at 25° C) and 127,620 (OAES at 10° C); and 41,395 (LCV at 25° C) and 171,261 (LCV at 15° C) respectively. The 0-10 cm profile from marsh soil has a range of values from 50,385 to 102,945 propagative units/g dry wt. soil (Table XXXVII).

These variations may be due in part to sources of error common

to the dilution plate technique such as variations in sampling and dilutions. However, other obvious sources of variation are loss of colonies due to overgrowth by faster growing species, and the effects of incubation temperatures, isolation media, and length of incubation time.

A comparison of average number of propagative units per gram dry weight of soil from all media, and temperatures for each profile, gives an indication of fungal propagule numbers throughout the beach ridge profile. The 10-20 cm profile has the largest propagule numbers with 339,672 propagative units per gram dry weight of soil (Table XXXIII). The 20-30 cm profile had the next largest value with 264,568 propagative units per gram dry weight (Table XXXIV). The 0-10 cm profile had the smallest propagule numbers per gram dry weight soil with 233,413 (Table XXXII). The 0-10 cm profile for marsh soil had a propagule level similar to beach ridge soil with 307,137 propagative units per gram dry weight of soil.

(b) Effect of Culture Media and Temperature on Propagule Numbers

In order to analyze the effect of temperature and media on the number of propagules isolated from beach ridge and marsh soils, Tables XXXV, XXXVI, XXXVIII and XXXIX were prepared.

The largest average number of propagules were isolated at all temperatures using OAES culture medium for both beach ridge (261,734 propagules/g dry wt. and marsh (96,481 propagules/g dry wt. soil profiles (Tables XXXVI and XXXVIII). The remaining culture media, in order of propagule numbers, were PDA, LCV, and SEA for beach ridge soil and PDA, SEA, and LCV for marsh soil.

TABLE XXXII

Fungal Propagule Numbers from Ridge Soil (Delta Marsh, Manitoba)
Total Propagule Numbers from the 0-10 cm Soil Fraction

Culture Medium	Number of Propagative Units per Gram Dry Weight of Soil								Total Number		Average Number	
	10° C		15° C		20° C		25° C					
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
LCV	57,600	924	72,000	448	36,000	1,064	40,800	756	206,400	3,192	51,600	798
	58,524		72,448		37,064		41,556		209,592		52,398	
SEA	57,600	224	55,200	280	48,000	616	64,800	392	225,600	1,512	56,400	378
	57,824		55,480		48,616		65,192		227,112		56,778	
OAES	60,000	476	76,800	252	69,600	560	57,600	84	264,000	1,372	66,000	343
	60,476		77,052		70,160		57,684		265,372		66,343	
PDA	+58,400	+541	76,800	364	60,000	504	93,600	308	*288,800	*1,697	*72,200	*424
	+58,941								230,400	1,176	76,800	392
	no data		77,164		60,504		93,908		*290,497		*72,200	
									231,576		77,192	
Total Number	175,200	1,624	280,800	1,344	213,600	2,744	256,800	1,540	926,400	7,252	231,600	1,813
	176,824		282,144		216,344		258,340		933,652		233,413	
Average Number	58,400	541	70,200	336	53,400	686	64,200	385	231,600	1,813		
	58,941		70,536		54,086		64,585		233,413			

\+ Dummy values.

* Adjusted value - dummy values substituted for missing data.

TABLE XXXIII

Fungal Propagule Numbers from Ridge Soil (Delta Marsh, Manitoba)
Total Propagule Numbers from the 10-20 cm Soil Fraction

Culture Medium	Number of Propagative Units per Gram Dry Weight of Soil								Total Number		Average Number	
	10° C		15° C		20° C		25° C					
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
LCV	81,628	224	96,000	532	112,800	532	52,800	NIL	343,228	1,288	85,807	322
	81,852		96,532		113,332		52,800		344,516		16,129	
SEA	67,200	476	67,200	448	69,600	672	93,600	252	297,600	1,848	74,400	462
	67,676		67,648		70,272		92,852		299,448		74,862	
OAES	127,200	420	96,000	354	64,800	252	112,800	56	400,800	1,082	100,200	271
	127,620		96,354		65,052		112,856		401,882		100,471	
PDA	+92,009	+ 373	108,000	196	84,000	336	120,000	308	*404,009	*1,213	*101,002	* 303
									312,000	840	104,000	280
	+92,382								*405,222		*101,305	
	no data		108,196		84,336		120,308		312,840		104,280	
Total Number	276,028	1,120	367,200	1,530	331,200	1,792	379,200	616	1,353,628	5,058	338,407	1,265
	277,148		368,730		332,992		379,816		1,358,686		339,672	
Average Number	92,009	373	91,800	383	82,800	448	94,800	205	338,407	1,265		
	92,382		92,183		83,248		95,005		339,672			

\+ Dummy values.

* Adjusted value - dummy values substituted for missing data.

TABLE XXXIV

Fungal Propagule Numbers from Ridge Soil (Delta Marsh, Manitoba)
Total Propagule Numbers from the 20-30 cm Soil Fraction

Culture Medium	Number of Propagative Units per Gram Dry Weight of Soil								Total Number		Average Number	
	10° C		15° C		20° C		25° C					
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
LCV	81,838	420	170,897	364	120,350	336	16,849	NIL	*1,386		* 347	
									380,034	1,120	97,509	373
	82,258		171,261		120,686		16,849		*391,420		*97,855	
									391,054		97,764	
SEA	NIL	364	79,431	336	40,919	728	40,919	476	*241,903		*60,476	
									161,269	1,904	53,756	476
	364		79,767		41,647		41,395		*243,807		*60,952	
									163,173		40,793	
OAES	79,431	280	NIL	55	81,838	588	115,536	56	*378,701		*94,675	
									276,805	979	92,268	245
	79,711		55		82,426		115,592		*379,680		*94,920	
									277,784		69,446	
PDA	+80,634	+ 355	55,361	+ 252 NIL	79,431	+ 551 NIL	91,466	+ 266 NIL	*306,892	+1,001	*76,723	* 250
									226,258	NIL	75,419	
	+80,990 NO DATA		+55,613 55,361		*79,982 79,431		*91,732 91,466		*307,893 226,258		*76,973 75,419	
Total Number	161,269	1,064	305,689	755	322,538	1,652	264,770	532	1,054,266	4,003	263,567	1,001
	162,333		306,444		324,190		265,302		1,058,269		264,568	
Average Number	80,634	355	101,896	252	80,635	551	66,193	266	263,567	1,001		
	80,990		102,148		81,186		66,459		264,568			

\+ Dummy values.
* Adjusted value - dummy values substituted for missing data.

TABLE XXXV

Fungal Propagule Numbers from Ridge Soil (Delta Marsh, Manitoba)
Average Propagule Numbers for all Temperatures
from the 0-10 cm, 10-20 cm and 20-30 cm Soil Fractions
Cultured on Four Different Culture Media

Soil Depth (cm)	Average Number of Propagative Units per Gram Dry Weight of Soil for 10°, 15°, 20° and 25° C								TOTAL	
	LCV		SEA		OAES		PDA			
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
0- 10	51,600	798	56,400	378	60,000	343	*72,200	*424	240,200	1,943
	52,398		56,778		60,343		72,624		242,143	
10-20	85,807	322	74,400	462	100,200	271	*101,002	*303	361,409	1,358
	86,129		74,862		100,471		*101,305		362,767	
20-30	97,509	*347	*60,476	476	*94,675	245	*76,723	*250	329,383	1,318
	97,856		*60,952		*94,920		*76,973		330,701	
TOTAL	234,916	1,467	191,276	1,316	254,875	859	249,925	977	930,992	4,619
	236,383		192,592		259,734		250,902		935,611	

* Dummy values.

TABLE XXXVI

Fungal Propagule Numbers from Ridge Soil (Delta Marsh, Manitoba)
Average Propagule Numbers for all Culture Media
from the 0-10 cm, 10-20 cm and 20-30 cm Soil Fractions
Cultured at Four Different Temperatures

Soil Depth (cm)	Average Number of Propagative Units per Gram Dry Weight of Soil									
	10° C		15° C		20° C		25° C		TOTAL	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
0-10	58,400	541	70,200	336	53,400	686	64,200	385	246,200	1,948
	58,941		70,536		54,086		64,585		248,148	
10-20	92,009	373	91,800	383	82,800	448	94,800	205	361,409	1,409
	92,382		92,183		83,248		95,005		362,818	
20-30	80,634	355	101,896	252	80,635	551	66,193	266	329,358	1,424
	80,990		102,148		81,186		66,459		330,782	
TOTAL	231,043	1,269	263,896	971	216,835	1,685	225,193	856	936,967	4,791
	232,312		264,867		218,520		226,049		941,748	

TABLE XXXVII

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Total Propagule Numbers from the 0-10 cm Soil Fraction

Culture Medium	Number of Propagative Units Per Gram Dry Weight of Soil								Total Number		Average Number	
	10° C		15° C		20° C		25° C					
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
LCV	14,100	44,935	17,100	42,845	10,200	44,935	11,100	59,565	52,500	192,280	13,125	48,070
	59,035		59,945		55,135		70,665		244,780		61,195	
SEA	24,000	74,195	18,600	38,663	18,900	81,510	21,000	51,205	82,500	245,573	20,625	61,393
	98,195		57,263		100,410		72,205		328,073		82,018	
OAES	18,300	84,645	24,000	72,105	14,400	74,195	10,500	87,780	67,200	318,725	16,800	79,681
	102,945		96,105		88,595		98,280		385,925		96,481	
PDA	9,048	51,205	15,900	34,485	18,400	57,475	21,600	61,655	64,948	204,820	16,237	51,205
	60,253		50,385		75,875		83,255		269,768		67,442	
Total Number	65,448	254,980	75,600	188,098	61,900	258,115	64,200	260,205	267,148	961,398	66,787	240,350
	320,428		263,698		320,015		324,405		1,228,546		307,137	
Average Number	16,362	63,745	18,900	47,025	15,475	64,529	16,050	65,051	66,787	240,350		
	80,107		65,925		80,004		81,101		307,137			

TABLE XXXVIII

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Average Propagule Numbers for all Temperatures
from the 0-10 cm Soil Fraction
Cultured on Four Different Culture Media

Soil Depth (cm)	Average Number of Propagative Units per Gram Dry Weight of Soil								TOTAL	
	LCV		SEA		OAES		PDA			
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
0-10	13,125	48,070	20,625	61,393	16,800	79,681	16,237	51,205	66,787	240,350
	61,195		82,018		96,481		67,442		307,137	

TABLE XXXIX

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Average Propagule Numbers for all Culture Media from the 0-10 cm Soil Fraction
Cultured at Four Different Temperatures

Soil Depth (cm)	Average Number of Propagative Units Per Gram Dry Weight of Soil									
	10° C		15° C		20° C		25° C		TOTAL	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
0-10	16,362	63,745	18,900	47,025	15,475	64,529	16,050	65,051	66,787	240,350
	80,107		65,925		80,004		81,101		307,137	

Analysis of the temperature effect on propagule numbers for these two sites yields different results (Table XXXVI). For beach ridge soil the largest average number of propagules per gram dry weight of soil were isolated at 15° C (264,867) followed by 10° C (232,312), 25° C (226,049) and 20° C (218,520) for the 0-30 cm profile. In marsh soil, the temperatures in order of average propagule numbers per gram dry weight soil were 25° C (81,101), 10° C (80,107), 20° C (80,004) and 15° C (65,925) for the 0-10 cm profile (Table XXXIX).

3. Frequency of Fungal Species

The percent frequency of fungal species was calculated for all species in each profile for beach ridge and marsh soils (Tables XLIX and L) using the formula:

$$\text{percent frequency} = \frac{\text{number of occurrences on all combinations of media and temperature}}{\text{total number of combinations of media and temperature}} \times 100$$

While results are not strictly comparable because of the difference in profile depths at the two sites, some interesting observations can be made.

(i) None of the beach ridge species has a percent frequency greater than 80, while the five most frequent species from the marsh soil (*Doratomyces nanus*, *Penicillium* cf *damascenum*, *Chrysosporium pannorum*, *Trichoderma viride*, and *Fusarium tabacinum*) have percentages between 81.3 and 100.

(ii) The Mycelia Sterilia form an important component of the beach ridge soil species with a frequency of 40%, while no Mycelia Sterilia forms were isolated from marsh soil.

TABLE XLIX

Percentage Frequency of Fungi Isolated from Ridge Soil (Delta Marsh, Manitoba) from the 0-30 cm Soil Fraction

Species Isolated	Percentage Frequency			
	0-10 cm	10-20 cm	20-30 cm	0-30 cm
Sphaeropsidales	73.3	73.3	66.7	71.1
Chrysosporium pannorum	80.0	66.7	53.3	66.7
Penicillium spp.	60.0	80.0	46.7	62.2
Trichoderma hamatum	53.3	40.0	66.7	53.3
Paecilomyces farinosus	40.0	40.0	66.7	48.9
Penicillium brevi-compactum	53.3	53.3	33.3	46.7
Penicillium cf. damascenum	53.3	46.7	40.0	46.7
Mycelia Sterilia	53.3	26.7	40.0	40.0
Penicillium cf. citrinum	33.3	46.7	33.3	37.8
Trichoderma harzianum	40.0	33.3	40.0	37.8
Cylindrocarpon tax. sp. 4	33.3	40.0	26.7	33.3
Gliocladium catenulatum	33.3	40.0	26.7	33.3
Phycomycetes	13.3	46.7	40.0	33.3
Fusarium spp.	26.7	20.0	26.7	24.4
Paecilomyces marquandii	26.7	33.3	13.3	24.4
Penicillium cf. canescens	33.3	20.0	20.0	24.4
Fusarium tabacinum	33.3	20.0	13.3	22.2
Penicillium cf. jenseni	20.0	20.0	13.3	17.8
Penicillium roseo-purpureum	13.3	33.3	6.7	17.8
Volutella ciliata	13.3	13.3	26.7	17.8
Beauveria bassiana	13.3	13.3	20.0	15.5
Fusarium tricinctum	6.7	20.0	20.0	15.5

TABLE XLIX (continued)

Percentage Frequency of Fungi Isolated from Ridge Soil (Delta Marsh, Manitoba) from the 0-30 cm Soil Fraction

Species Isolated	Percentage Frequency			
	0-10 cm	10-20 cm	20-30 cm	0-30 cm
Doratomyces nanus	13.3	20.0	6.7	13.3
Myrothecium roridum	20.0	6.7	13.3	13.3
Penicillium nalgiovensis	20.0	20.0		13.3
Penicillium steckii	6.7	20.0	13.3	13.3
Acremonium crotocinigenum	13.3	6.7	13.3	11.1
Acremonium strictum	13.3	6.7	13.3	11.1
Kernia packypleura	13.3	13.3	6.7	11.1
Mortierella alpina	13.3	13.3	6.7	11.1
Alternaria alternata	6.7	6.7	13.3	8.9
Fusarium graminearum	13.3	6.7	6.7	8.9
Fusarium solani	6.7	13.3	6.7	8.9
Gliocladium roseum	13.3	13.3		8.9
Cladosporium spp.	6.7	6.7	6.7	6.7
Cylindrocarpon tax. sp. I	6.7	6.7	6.7	6.7
Fusarium arthrosporioides	13.3	6.7		6.7
Fusarium lateritium	6.7	6.7	6.7	6.7
Penicillium expansum	6.7	6.7	6.7	6.7
Phialophora fastigiata	6.7	13.3		6.7
Rhinocladiella mansonii	13.3		6.7	6.7
Verticillium lecanii		6.7	13.3	6.7
Verticillium tenerum	6.7	13.3		6.7
Cylindrocarpon sp.	6.7		6.7	4.4

TABLE XLIX (continued)

Percentage Frequency of Fungi Isolated from Ridge Soil (Delta Marsh, Manitoba) from the 0-30 cm Soil Fraction

Species Isolated	Percentage Frequency			
	0-10 cm	10-20 cm	20-30 cm	0-30 cm
Fusarium oxysporum	6.7	6.7		4.4
Mortierella spp.	6.7	6.7		4.4
Penicillium janthinellum		13.3		4.4
Penicillium nigricans	6.7	6.7		4.4
Penicillium oxalicum	6.7	6.7		4.4
Phoma fimeti	6.7		6.7	4.4
Pyrenochaeta acicola	6.7		6.7	4.4
Taxonomic genus #1	6.7		6.7	4.4
Verticillium tax. sp. 1	6.7	6.7		4.4
Acremonium sclerotigenum	6.7			2.2
Acremonium sp.		6.7		2.2
Arthroderma curreyi (con. state)			6.7	2.2
Ascodesmis sphaerospora			6.7	2.2
Chaetomium spp.		6.7		2.2
Chrysosporium spp.		6.7		2.2
Cladosporium spp.	6.7			2.2
Cylindrocarpon tax. sp. 2	6.7			2.2
Fusarium poae	6.7			2.2
Fusarium semitectum		6.7		2.2
Hormiactus alba		6.7		2.2
Mortierella hyalina			6,7	2.2
Paecilomyces spp.		6.7		2.2
Penicillium cf. *claviforme*		6.7		2.2

TABLE XLIX (continued)

Percentage Frequency of Fungi Isolated from Ridge Soil (Delta Marsh, Manitoba) from the 0-30 cm Soil Fraction

Species Isolated	Percentage Frequency			
	0-10 cm	10-20 cm	20-30 cm	0-30 cm
Penicillium notatum		6.7		2.2
Penicillium rolfsii	6.7			2.2
Penicillium vinaceum		6.7		2.2
Peziza ostracoderma (con st.)			6.7	2.2
Phialophora malorum		6.7		2.2
Phoma glomerata			6.7	2.2
Pyrenochaeta tax. sp. I			6.7	2.2
Stachybotrys cf. atra			6.7	2.2
Trichoderma polysporum	6.7			2.2
Trichosporon sp.		6.7		2.2
Ulocladium atrum		6.7		2.2
Verticillium lamellicola		6.7		2.2
Verticillium nigrescens		6.7		2.2
Volutella sp.			6.7	2.2
Wardomyces anomalus	6.7			2.2

TABLE L

Percentage Frequency of Fungi Isolated from Marsh Soil (Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction

Species Isolated	Percentage Frequency
Doratomyces nanus	100.0
Penicillium cf. damascenum	100.0
Chrysosporium pannorum	87.5
Trichoderma viride	87.5
Fusarium tabacinum	81.3
Cylindrocarpon tax. sp. 3	75.0
Fusarium graminearum	75.0
Penicillium nigricans	75.0
Trichoderma harzianum	75.0
Phycomycetes	68.8
Paecilomyces marquandii	62.5
Verticillium nigrescens	62.5
Botryotrichum piluliferum	56.3
Cylindrocarpon tax. sp. 5	56.3
Penicillium spp.	56.3
Acremonium persicinum	50.0
Fusarium spp.	31.3
Trichoderma hamatum	31.3
Acremonium strictum	25.0
Penicillium brevi-compactum	25.0
Sporotrichum epigaeum var. terrestre	25.0
Doratomyces putredinis	18.8

TABLE L (continued)

Percentage Frequency of Fungi Isolated
from Marsh Soil (Delta Marsh, Manitoba)
from the 0-10 cm Soil Fraction

Species Isolated	Percentage Frequency
Fusarium sporotrichioides	18.8
Fusarium tricinctum	18.8
Mariannaea elegans var. elegans	18.8
Penicillium cf. canescens	18.8
Sphaeropsidales	18.8
Taxonomic genus #1	18.8
Verticillium lecanii	18.8
Verticillium spp.	18.8
Acremonium furcatum	12.5
Acremonium sp.	12.5
Mortierella spp.	12.5
Paecilomyces spp.	12.5
Penicillium cf. jenseni	12.5
Penicillium stoloniferum	12.5
Rhinocladiella mansonii	12.5
Sporothrix sp.	12.5
Alternaria alternata	6.3
Arthrinium phaeospermum	6.3
Botrytis cinerea	6.3
Chaetomium funicolum	6.3
Chaetomium spp.	6.3
Chrysosporium merdarium var. roseum	6.3

TABLE L (continued)

Percentage Frequency of Fungi Isolated
from Marsh Soil (Delta Marsh, Manitoba)
from the 0-10 cm Soil Fraction

Species Isolated	Percentage Frequency
Chrysosporium sp.	6.3
Cladosporium spp.	6.3
Cylindrocarpon sp.	6.3
Dactylaria scaphoides	6.3
Emericellopsis sp.	6.3
Fusidium cf. *griseum*	6.3
Gliomastix cerealis	6.3
Mortierella alpina	6.3
Myrothecium roridum	6.3
Paecilomyces farinosus	6.3
Penicillium cf. *claviforme*	6.3
Penicillium expansum	6.3
Penicillium frequentans	6.3
Phialophora fastigiata	6.3
Phialophora malorum	6.3
Phialophora sp. nov.	6.3
Plenodomus sp. nov.	6.3
Pyrenochaeta sp.	6.3
Rhinocladiella cf. *anceps*	6.3
Stachybotrys cf. *atra*	6.3
Trichurus spiralis	6.3
Verticillium dahliae	6.3

TABLE L (continued)

Percentage Frequency of Fungi Isolated
from Marsh Soil (Delta Marsh, Manitoba)
from the 0-10 cm Soil Fraction

Species Isolated	Percentage Frequency
Verticillium lamellicola	6.3
Verticillium tenerum	6.3

(iii) Many of the species which inhibit the greatest frequency of occurrence are different when marsh and beach ridge soils are compared. Seven of the ten most frequent species for both beach ridge and marsh are significantly different in their ranking by percent frequency. Only three of the 10 most frequent species are common for both sites: Chrysosporium pannorum, Penicillium cf damascenum, and Trichoderma harzianum, and their site rankings vary. Two of the 10 most frequent species for both sites are site specific - the Mycelia Sterilia and Penicillium cf citrinum from beach ridge soil; and Trichoderma viride and Cylindrocarpon tax. sp. 3 from marsh soil.

(iv) The percentage of species which occur only once is higher in marsh soil (44%) than beach ridge soil (33.3%).

(v) Marsh soil has a more diverse flora in the 0-10 cm profile. Fifty-seven species were isolated from the 0-10 cm profile from the beach ridge as compared to 68 species from the marsh soil.

(vi) Many of the most frequent species for both sites are common to both sites, but with varying frequency rank. The most frequently occurring fungi are different for both sites. e.g. the Sphaeropsidales, most frequent (71.1%) in beach ridge soil, is 27th in marsh soil (18.8%); Doratomyces nanus, the most frequent species in marsh soil (100%), is 23rd in beach ridge soil (13.3%). Of the species with a frequency greater than 25%, 75% of beach ridge species are common to marsh soil, while 71% of those marsh species are also common to beach ridge soil.

(vii) It is the rare species which make the greatest overall difference in the fungal flora of these two sites, e.g. 50% of the 30 single occurrence (rare) species from marsh soil

are site specific, while 67% of the 27 single occurrence species from beach ridge soil are site specific.

4. Vertical Distribution of Beach Ridge Fungi

Based on vertical distribution, three groups of beach ridge soil fungi are evident.

The largest group of fungi, 36 species (44% of all species) occur in all three soil profiles. A second smaller group, 29 species (36% of all species) were isolated from only one soil profile. The third and smallest group, 16 species (20% of all species) was isolated from two of three soil profiles.

When the list of those fungi from a single profile is further analyzed, it is apparent that the largest number, 14 species (17% of all species) came from the 10-20 cm profile. Eight species (10% of all species) were isolated from the 20-30 cm soil profile, while seven species (9% of all species) were found only at 0-10 cm.

The distribution of fungi from two of the three soil profiles was greatest in the 0-20 cm fraction - 10 species (12% of all species). The 0-10 cm and 20-30 cm profile combination had five species (6% of all species). One species (1% of all species) was isolated from only the 10-30 cm fraction.

It is apparent from Table XLIX that the most frequently occurring species of fungi from beach ridge soil occur throughout the 0-30 cm profile. Of the 38 species with a frequency greater than 6.7% only three species, Penicillium nalgiovensis, Gliocladium roseum, and Fusarium arthrosporioides, did not occur in all three profiles. Individually 72% (58 of 81 species) of all beach ridge fungi were isolated from the 0-10

cm profile, 77% (62 of 81 species) from the 10-20 cm profile, and 62% (50 of 81 species) were present in the 20-30 cm profile (Table XLIX).

5. Effect of Temperature and Media on Fungal Diversity

(a) Temperature Effects

The occurrence of fungi isolated on all culture media at each temperature was recorded for each 10 cm soil profile from the beach ridge (Appendix E, Tables XLI-XLIII). Those fungi isolated from the 0-10 cm profile from marsh soil were also recorded by incubation temperature (on all media) in Table XLVIII (Appendix E).

In order to establish the relationship between incubation temperature and the number of different fungi isolated (fungal diversity) on all culture media, Tables LI and LII were prepared for beach ridge soil and marsh soil respectively. For beach ridge soil, a common pattern of fungal diversity, as affected by incubation temperature, emerges.

The greatest fungal diversity, as reflected by percent of species isolated, occurs at higher temperatures, i.e. 20° C and 25° C while at lower temperatures, 10° C and 15° C, reduced fungal diversity occurs (Table LI). This pattern was the same for each 10 cm profile as well as for the entire 0-30 cm profile. The percent of species isolated at the same temperature for different profiles shows variation but, in general, the values are comparable. When the data for the entire 30 cm profile is examined the grestest fungal diversity occurred at 20° C (61%), followed by 25° C (57%), 15° C (47%) and 10° C (37%).

The single 0-10 cm marsh soil profile does not show the same pattern of fungal diversity in relation to incubation temperature as does

TABLE LI

Percent Fungi Isolated From Beach Ridge Soil by Soil Depth and Temperature

Depth (cm)	Temp. (°C)	No. of Species Isolated of Total Species at Temperature and Depth	% of Species Isolated at Temperature and Depth
0-10	20	33/58	57
	25	30/58	52
	15	25/58	43
	10	19/58	33
10-20	25	32/62	52
	20	30/62	48
	15	28/62	45
	10	24/62	39
20-30	20	32/50	64
	25	28/50	56
	15	21/50	42
	10	14/50	28
0-30	20	49/81	61
	25	46/81	57
	15	38/81	47
	10	30/81	37

TABLE XLII

Percent of Fungi Isolated From Marsh Soil by Temperature From the 0-10 cm Profile

Depth (cm)	Temperature (^{o}C)	Number of Species Isolated of Total Species at Temperature and Depth	% of Species Isolated at Temperature at Depth
0-10	15	39/68	57
	20	37/68	54
	25	34/68	50
	10	33/68	49

the 0-30 cm beach ridge profile. Rather than very distinct differences in fungal diversity between the four incubation temperatures, a narrow range from 49% to 57% exists (Table LII). While fungal diversity is least (49%) at an incubation temperature of 10° C (as was beach ridge soil) the order of the remaining three temperatues is almost the reverse of that for beach ridge soil, i.e. 15°C (57%), 20° C (54%) and 25° C (50%).

The fungal diversity (as percent of species isolated) is similar for three of four incubation temperatures (15° C, 20° C and 25° C) for the 0-10 cm profile of both sites. The incubation temperature with the least fungal diversity, 10° C, has a large disparity in the percent of species isolated between sites; 33% for beach ridge soil and 49% for marsh soil.

(b) Media Effects

Tables XLIV - XLVI (Appendix E) record the occurrence of those fungi isolated at all incubation temperatures on each culture medium for each 10 cm beach ridge soil profile. Fungi occurring in the 0-10 cm soil profile from marsh soil were recorded for each culture medium for all incubation temperatures in Table XLVII (Appendix E).

As with incubation temperature tables for each site were prepared to elucidate the effect of culture conditions (culture medium) on fungal diversity (Tables LIII and LIV).

OAES culture medium produced the greatest fungal diversity (as percent of species isolated) for each of the 10 cm beach ridge soil

TABLE LIII

Percent Fungi Isolated From Beach Ridge Soil
by Soil Depth and Culture Medium

Depth (cm)	Culture Medium	Number of Species Isolated of Total Species On Culture Medium at Depth	% of Species Isolated on Culture Medium at Depth
0-10	OAES	35/58	60
	PDA	27/58	47
	LCV	26/58	45
	SEA	20/58	35
10-20	OAES	33/62	53
	SEA	33/62	53
	LCV	25/62	40
	PDA	22/62	36
20-30	OAES	31/50	62
	LCV	29/50	58
	SEA	20/50	40
	PDA	18/50	36
0-30	OAES	51/81	63
	LCV	41/81	51
	SEA	36/81	44
	PDA	34/81	42

TABLE XLIV

Percent Fungi Isolated From Marsh Soil
by Culture Medium From the 0-10 cm Profile

Depth (cm)	Culture Medium	Number of Species Isolated of Total Species On Culture Medium at Depth	% of Species Isolated on Culture Medium at Depth
0-10	OAES	42/68	61
	SEA	37/68	54
	PDA	29/68	42
	LCV	20/68	29

profiles, i.e. 0-10 cm - 60%, 10-20 cm - 53%, and 20-30 cm - 62%. The fungal diversity of the three remaining culture media varied throughout the three profiles. However, the percent values of second, third and fourth rated media were comparable for each of the three profiles.

When the fungal diversity of the entire 30 cm profile is considered, 63% of all fungi were isolated on OAES culture medium. LCV, SEA, and PDA follow with 51%, 44% and 42% respectively.

OAES culture medium also produced the greatest fungal diversity in the 0-10 cm marsh soil profile with 61% of all species isolated (Table LIV). The rank of the other three media was SEA (54%), PDA (42%) and LCV (29%).

A comparison of fungal diversity in the 0-10 cm profile from the two sites indicates that while the percent of species isolated is similar, the ranking of the media is the same for only OAES, the first ranked medium.

6. Effect of Temperature and Culture Media on Species Composition

It is important to report, where possible, the effect of temperature and media on the isolation of specific species of fungi. To accomplish this Tables XLI - XLVI (Appendix E) and XLIX for beach ridge soil, and Tables XLVII, XLVIII (Appendix E), and L for marsh soil, were used.

(a) Temperature Effects

Most of the frequently occurring species for both beach ridge and marsh soils are not restricted by temperature or media, i.e. they

are isolated at all temperatures on all media. Eight species, or group representatives (Sphaeropsidales, Chrysosporium pannorum, Penicillium spp., Trichoderma hamatum, Penicillium brevi-compactum, Penicillium cf. damascenum, Mycelia Sterilia and Phycomycetes), with a frequency between 33.3% and 71.1%, were common to beach ridge soil on all media and at all temperatures. Marsh soil had 12 species or group representatives (Doratomyces nanus, Penicillium cf. damascenum, Chrysosporium pannorum, Trichoderma viride, Fusarium tabacinum, Cylindrocarpon tax. sp. 3, Fusarium graminearum, Penicillium nigricans, Trichoderma harzianum, Phycomycetes, Botryotrichum piluliferum and Penicillium spp.) between 56.3% and 100% frequency which occurred on all media at all temperatures.

A small number of species (6) from beach ridge soil were apparently restricted by temperature only, i.e. they were isolated on all media, but not at all temperatures. Three of these species, Paecilomyces farinosus, Trichoderma harzianum and Gliocladium catenulatum, did not occur at 10°C. Penicillium roseo-purpureum and Volutella ciliata were not isolated at 15° C, while Acremonium crotocinigenum was not isolated at either 10° C or 15° C. The frequency of these possibly restricted species was between 11.1% and 48.9%. None of the species isolated from marsh soil appeared to be restricted by temperature but not media.

A second group of fungi, generally of lower frequency of occurrence than those previously mentioned, was isolated neither on all media nor at all temperatures. Because of their low frequency, it is difficult to distinguish between the effect of chance distribution of propagules during dilution plating and restrictive effects caused by temperature and/or media. However, at least two marsh soil species appear to be restricted by temperature. Trichoderma hamatum (frequency

31.3%) was isolated on three different culture media but only at 20° C and 25° C; Mariannaea elegans var. elegans (frequency 18.8%) occurred on three media but only at 25° C. Myrothecium roridum (frequency 13.3%) from beach ridge soil, was also isolated on three culture media but not at 10° C.

Sixteen infrequent (less than 20%) species from beach ridge or marsh soil were isolated on two culture media and had a pattern of temperature restriction, i.e. they were isolated at only higher (20° C - 25° C) or lower temperatures (10° C - 15°C). Among these, two species isolated from both sites showed the same pattern of temperature restriction; Penicillium cf. jensenii and Mortierella alpina were isolated at higher temperatures only.

(b) Culture Media Effects

The twenty fungi which were isolated on all media at all temperatures have been previously mentioned, and in general they are the most frequent fungi from both sites. Fungi appear to be restricted in occurrence by certain culture media, as they do at certain incubation temperatures. Five marsh species which were isolated at all temperatures were not isolated on all media. These include Acremonium persicinum, Paecilomyces marquandii and Verticillium nigrescens which did not occur on LCV culture medium. Sporotrichum epigaeum var. terrestre and Penicillium brevi-compactum were not isolated on LCV and PDA and LCV and SEA respectively. These species have a range of frequencies from 25% to 62.5%. Beach ridge soil isolates in the same category were Penicillium cf. citrinum, Fusarium tabacinum and Paecilomyces marquandii for PDA and Cylindrocarpon tax. sp. 4 and Penicillium cf. canescens for SEA culture medium. Frequency of occurrence for this group ranged from

22.2% to 37.8%.

Rare fungi isolated at three of four incubation temperatures but not on all media occurred in both beach ridge and marsh soils. Myrothecium roridum (SEA), Alternaria alternata (OAES, PDA) and Penicillium steckii (PDA) from beach ridge soil and Penicillium cf. canescens (OAES, PDA) from marsh soil, were not isolated on the bracketed media.

Other species of fungi from marsh and beach ridge soils were limited in occurrence by temperature and had a pattern of media restriction. However, their low frequency of occurrence, and lack of concurrence between the two sites, suggests that their restrictions are coincidental rather than the selective effect of culture media.

DISCUSSION

1. Species Composition

(a) Beach Ridge Soil

The dominant fungi of beach ridge soil resemble those of other near neutral sandy soils of low organic content; specifically the dune soils of England and Lake Michigan U.S.A., (Brown, 1958; Dickinson and Kent, 1972; Pugh, 1963; Pugh et al, 1963; Wohlrab et al, 1963). Twenty-seven species are common to beach ridge soil and one or more of the dune soils. The most frequent species, while not always identical, fall into the same dominant group or genera namely Acremonium or Cephalosporium, Penicillium, Fusarium, Paecilomyces, Trichoderma, Myrothecium, Phycomycetes, and Sphaeropsidales. While strict comparisons between the species composition of these soils is questionable because vegetation, soil profiles, culture techniques, identification procedures and calculation of frequency of occurrence differ, major variations are worthy of mention. These are, for the most part, differences or variations in species composition within dominant genera or differences in frequency of common species between sites. Not unexpectedly the species composition of infrequent or rare species also varies between these sites.

Only three of 17 Penicillium species from beach ridge soil, P. nigricans, P. oxalicum and P. brevi-compactum, were reported in dune soils. While Penicillium brevi-compactum is a common and frequent species at all three sites, Penicillium cf. damascenum, a variant of P. damascenum, is co-dominant with the P. brevi-compactum in beach ridge soil. P. damascenum has not previously been reported in Manitoba soils nor does it appear to have been reported in North American soils. The abundance of Penicillium species in this study is likely due in part to a more complete identification of Penicillium isolates than that of other workers.

Within the genus Fusarium only two of nine species from beach ridge soil, F. oxysporum and F. solani, are common in dune soils. The most frequent species from beach ridge soil, F. tabacinum and F. tricinctum, have not been reported in dune soils and are also new reports for Manitoba soils. Saito (1955) and Brown (1958) have suggested that Fusarium species are confined to organic matter within sand dunes. The presence of Fusarium species in organic particles in soil has been attributed to the ability of species to produce intercalary chlamydospores (Gams and Domsch, 1969).

Parkinson and Kendrick (1960), Parkinson and Thomas (1965), Thomas and Parkinson (1967), and Williams et al (1965), have all noted the increase of Fusarium species following soil washing. The removal of Fusarium propagules from soil by washing, combined with the identification of as many species as possible rather than only dominant forms, helps account for increased numbers of species within this genus vis a vis dune soils.

The wash technique is also likely responsible for the appearance of the Mycelia Sterilia as a dominant or frequent component in beach ridge soils. This group was not reported as an important component in dune soils. Parkinson and Williams (1961) and Williams et al (1965) noted increased frequency of isolation of sterile forms from washed soil.

A difference in the composition of Trichoderma species is obvious when dune and beach ridge soils are compared. Trichoderma hamatum is a common species in beach ridge soil while Trichoderma viride is dominant in dune soils. Both species are known to be colonizers of organic matter in soil (Bisby et al, 1933; Chesters, 1960; Danielson and Davey, 1973; Gams and Domsch, 1969; Thomas and Parkinson, 1967; Williams et al, 1965).

Chrysosporium pannorum was reported by Dickinson and Kent (1972) as a cellulose decomposer in coastal dunes. C. pannorum and other Chrysosporium spp. have also been isolated from organic soil particles (Williams et al, 1965), and washed soil (Widden and Parkinson, 1979). The high frequency of occurrence (66.7%) of Chrysosporium pannorum relative to dune soils suggests a significant difference in environmental conditions. Williams et al have suggested that Chrysosporium spp. colonize small organic fragments followed by lateral spread through soil. The sandy beach ridge soil containing organic lenses likely presents a favorable environment for the growth and spread of Chrysosporium pannorum.

Other species common to beach ridge but not dune soils include Paecilomyces marquandii and Gliocladium catenulatum. While all dune sites had one Gliomastix species as a common component, no species of this genus were isolated from beach ridge soil.

Among the rare or infrequent species isolated were several species uncommon to dunes. Phialophora fastigiata and Phialophora malorum, commonly associated with organic matter in soil, are infrequently isolated except by soil washing (Bhatt, 1970). Rhinocladiella mansonii, Peziza ostracoderma, and Volutella ciliata were first reported in Canadian soil by Bhatt (1970). The occurrence of Kernia pachypleura is a new report for North America. Five undescribed species of Cylindrocarpon were also isolated.

(b) Marsh Soil

The lack of soil studies from communities similar to the one reported on here makes intersite comparisons of microfungi difficult. The four most similar sites regarding microfungal composition are a

British fen (Stenton, 1953), a Canadian Cedar bog (Bhatt, 1970), British salt marsh (Pugh, 1962) and the Florida Everglades (U.S.A.) (Wallace and Dickinson, 1978). While both the predominant groups or genera of fungi [Acremonium (Cephalosporium), Fusarium, Myrothecium, Paecilomyces, Phycomycetes, Sphaeropsidales, Trichoderma], as well as many species (40) are common to these sites, major differences exist when the dominant species are compared.

Eight of the 12 most frequent species from marsh soil are either uncommon or unreported from the Cedar bog, fen, salt marsh and Everglade soils. These species include Doratomyces nanus, Penicillium cf. damascenum, Chrysosporium pannorum, Fusarium tabacinum, Cylindrocarpon tax. sp. 3, Fusarium graminearum, Trichoderma harzianum and Cylindrocarpon tax. sp. 5. Most of these species, or species from these genera, are either known cellulose decomposers, or are routinely isolated from organic fragments in soil (Chesters, 1960; Parkinson and Williams, 1961; Thomas and Parkinson, 1967; Williams and Parkinson, 1964; Williams et al, 1965). None of these species has been previously reported in Manitoba soil, although the perfect state of Fusarium graminearum (Gibberella zeae) was reported on plant parts (Gordon, 1944).

Fungi commonly isolated from other organic soils but missing from marsh soil isolates are Gliocladium spp. and sterile mycelial forms. The most common Gliocladium species, G. catenulatium and G. roseum, were however isolated from beach ridge soil. The absence of sterile mycelial forms from marsh soils is unexpected since it has been shown that these forms are frequently associated with organic matter in soil and are isolated with increased frequency from wash soil (Williams et al, 1965). It is possible that insufficient washing failed to remove a large enough

fraction of spores of faster growing species to prevent excessive competition on culture plates. Approximately 22% of all isolates came from wash water, while the remaining 78% came from diluted washed soil. Bhatt (1970) isolated a large component consisting of Mycelia Sterilia from diluted blendermixed Cedar bog soil. This may indicate that the mechanical disruption of organic soil is necessary for satisfactory isolation of sterile mycelial forms. The possibility also exists that such forms are not a principal component of the upper profile of marsh soil. Sewell (1959 a) noted an increase in dark sterile forms with increasing soil depth, and he had difficulty in isolating these forms from the upper soil horizons of Calluna - heathland soils.

An increase in the number of species of the genera Acremonium, Penicillium, and Verticillium was also noted when marsh soil isolates were compared to those of other organic soils. This is likely a reflection of identification procedures rather than real differences in species composition.

Within the group of rare or infrequent species were four species (Beauveria bassiana, Paecilomyces farinosus, Rhinocladiella anceps and Rhinocladiella mansonii) first recorded from Canadian soil (Cedar bog soil) by Bhatt (1970). Chrysosporium merdarium var. roseum, Dactylaria scaphoides (a nematophagous fungus), Doratomyces putredinis, and Trichurus spiralis were also isolated infrequently here but were unreported from the other comparable organic soils.

While attempts have been made to explain the predominance or lack of certain fungi from the two Delta Marsh soils a final factor should be considered. The use of sixteen sets of culture conditions for the growth and isolation of fungi in this study contrasts sharply with those

of other studies. The appearance of at least some of the more infrequent species is probably the result of this effort.

2. Vertical Distribution of Fungi

The fungal propagule numbers for beach ridge soil profiles are unusual when compared to most soil profiles. The "typical" pattern for soil fungi is for propagule numbers to be highest at the surface or A horizon, and to decrease with depth through the B and C horizons (Newman and Norman, 1943; Stenton, 1953). In beach ridge soil, the A and B horizons are not developed and profiles are representative of soil depth rather than soil layers. Here the smallest populations occur at the surface (0-10 cm) and are largest in mid profile (10-20 cm). Three factors, temperature, moisture, and organic content, either separately or in combination, are likely responsible for this pattern. The surface temperature of the beach ridge soil which is higher than that of lower profiles, may be high enough to suppress the growth of surface populations of fungi. (While no temperature data was collected during this study I have collected data from beach ridge soil demonstrating this phenomenon.) Wohlrab et al (1963) noted this effect in exposed Lake Michigan dune soils.

The warmer surface temperature, combined with good soil drainage on the raised sandy ridge, produces a noticeably dry surface profile. This lack of moisture was obvious when soil cores were removed. Moisture levels have been well documented as an important environmental factor controlling both the number and composition of soil microfungi (Bissett and Parkinson, 1979 a, 1979 c; Miller and Laursen, 1974; Wicklow et al, 1974; Wohlrab et al, 1963). Lower soil moisture usually leads to a reduction in numbers and diversity of soil fungi.

During the removal of soil cores from the beach ridge, it was

apparent that the lower profiles contained a number of organic lenses or layers. The surface profile, even where covered with vegetation, lacked this feature. The presence of this organic material can likely be correlated with larger numbers of propagative units in lower soil profiles. The lack of developed L, F and H soil horizons which normally stimulate the growth of surface population, further contributes to the reduction in upper profile fungal propagules (Newman and Norman, 1943). Gochenauer and Whittingham (1967) have suggested that increased numbers of microfungi in the soils of willow-cottonwood forests are correlated with increased organic matter. In addition, it may be possible that the fungal population in lower profiles of beach ridge soils is stimulated by the rhizosphere effect.

The fungal diversity of the beach ridge soil profiles is similar to that of other soils, i.e. decreasing diversity of sporulating fungi with soil depth (Bissett and Parkinson, 1979 a; Newman and Norman, 1943; Sewell, 1959 a, 1959 b; Widden and Parkinson, 1973). The dominant or most frequent fungi in beach ridge soil are distributed throughout the entire 0-30 cm profile while the less frequent or rare species are discontinuous. This pattern of species distribution is similar to that of fungi from Canadian coniferous forest soils (Widden and Parkinson, 1973).

While a larger population is found in the lower beach ridge soil horizons than at the surface, a greater diversity of species (72% of all species) is found in the 0-10 cm profile compared to the 20-30 cm profile (62% of all species). This may reflect enhanced conditions for growth and reproduction of fungi in the moister lower soil profile. The upper profile (0-10 cm) obviously contains a greater variety of species but

with lower reproductive or growth rates, possibly because of environmental factors. In the mid profile (10-20 cm) environmental conditions are similar to the 20-30 cm profile, species diversity is greatest (77% of all species). This appears to be an atypical pattern.

3. Temperature and Media Effects

(a) Temperature Effects

The effect of incubation temperature on the number of fungi isolated from beach ridge and marsh soil is not entirely clear. The greatest number of isolates occurred at low temperatures (10^{o} C and 15^{o} C) for beach ridge soil, while there was little difference between the number of marsh isolates at 25^{o} C, 10^{o} C and 20^{o} C. In general fewer isolates were lost because of plate overgrowth by highly competitive or fast growing species at lower incubation temperatures. Since only those colonies isolated were counted, the lower propagule numbers at higher incubation temperatures for beach ridge soil may be artificial. It may also be explained on the order in which plates were removed from the incubator; plates were usually removed from lower temperatures last. This may have allowed for more complete germination of propagules because of the longer incubation period, and produced more discrete colonies due to the reduced radial growth at the lower incubation temperature. The combined effect of this would be reflected in a larger number of colonies isolated at lower temperatures. The consistency of propagule numbers for marsh soil may indicate the absence of any real effect of temperature on the number of fungi isolated.

An examination of the effect of temperature on fungal species diversity yields the same pattern for beach ridge and marsh soils. In

both soils a greater diversity of fungi occurred at incubation temperatures yielding the lowest number of propagative units. This may indicate that temperatures which promote the best growth do so for those species with the greatest number of propagative units, i.e. the most competitive species. The only pattern which does appear to be clear is that at the lowest incubation temperature (10° C), large numbers of propagules germinate and grow, but this condition produces the least species diversity.

When the restrictive effect of incubation temperature on the occurrence of distinct species of fungi is examined, the majority of species restricted by incubation temperature are uncommon soil fungi rather than cosmopolitan forms, e.g. Acremonium crotocinigenum, Marriannea elegans var. elegans, Myrothecium roridum, and Volutella ciliata. In addition all species are restricted only at low temperatures (10° C or 15° C). Two species of the cosmopolitan genus Trichoderma (T. hamatum from marsh soil and T. harzianum from beach ridge), were restricted by incubation temperature. Danielson and Davey (1973) examined the climatic distribution of Trichoderma species and suggested T. harzianum was characteristic of warm climates. Bissett and Parkinson (1979 a) noted the absence of Trichoderma species from the high Arctic or alpine tundra. Trichoderma viride, while occurring at all temperatures in this study, was shown to compete better at 25° C as opposed to 15° C (Dickinson and Kent, 1972).

(b) Culture Media Effects

Examination of the effect of culture media on propagative number reveals a similar pattern for both marsh and beach ridge soil. OAES

isolation medium recovered the greatest number of isolates followed by PDA medium; SEA and LCV media were the least effective media.

The growth of fungi from both marsh and beach ridge soil on SEA medium was usually meagre or sparse, making it more difficult to detect and isolate colonies in comparison with other culture media: this resulted in loss of fungi. In addition, many isolated colonies were contaminated by undetected spreading fungi. The overgrowth of plates by fast growing and spreading fungi was pronounced on older LCV medium dilution plates, also resulting in loss of colonies before isolation. Mycelial growth of fungi isolated from marsh soil on LCV medium was in contrast to the beach ridge soil dilution plates on LCV medium. i.e. colonies were fewer and more discrete. Marsh soil samples also yielded noticeably fewer colonies when plated on LCV medium than on the other three culture media.

The large number of colonies growing on, and isolated from, both OAES and PDA media is probably due to nutritional effects. For OAES medium, the larger number of colonies isolated may be due to the presence of sodium propionate, a growth inhibitor not present in the other culture media. Sodium propionate is known to reduce the mycelial growth rate of fungi. It may have produced more discrete colonies and suppressed the spreading of faster growing fungi compared to other culture media.

OAES, the culture medium yielding the greatest number of colonies, also produced the greatest species diversity. This effect is unlike that found for temperature, i.e. the temperatures recovering the greatest number of fungi yielded the least species diversity. Schmitthenner and Williams (1958) compared OAES medium to a number of common media and

noted a similar effect; OAES medium recovered the greatest number and most diverse species of fungi. While PDA yielded a large number of isolates, the species diversity was considerably reduced compared to SEA and LCV media, both of which yielded more diverse isolates than PDA medium. This phenomenon has at least two possible causes. First, no beach ridge soil sample was plated on PDA at 10° C, likely reducing slightly the range of species isolated on PDA medium. Second, and more importantly, a large number of the propagules isolated from PDA were from Trichoderma and Penicillium, two genera known to sporulate profusely in soil. The frequent occurrence of species within these genera on PDA medium suggests that their spores are able to germinate and grow more rapidly on PDA than other less frequently occurring fungi. This effect is well known on soil dilution plates and soil plates using unwashed soil.

Litmans Crystal Violet medium, when used for the isolation of fungi from beach ridge soil, had the opposite effect to that of PDA medium, i.e. while propagule numbers were small compared to PDA medium, species diversity was greater. Marsh soil plated on LCV medium produced both small propagule numbers and little species diversity. This result may reflect differences between the organic matter content of these soils. Certain fungi characteristic of organic soils, e.g. Phialophora spp., Acremonium spp. and Verticillium spp., were not isolated on LCV medium from marsh soil.

The number of isolates obtained from marsh soil on soil extract agar medium was second only to OAES medium in diversity, while propagule numbers weremuch smaller. This is possibly related to the similarity between soil extracts and the organic residues available to fungi in

organic soils. Jensen (1931) noted that the presence of decomposable organic material stimulated fungal activity in soil. It seems reasonable that this phenomenon would also be exhibited when fungi are transferred from soil to culture media. Other workers (Sewell, 1959 a, 1959 b, 1959 c; Pugh (1963), Wallace and Dickinson (1978), have successfully used SEA medium for the isolation of a range of fungi from soil.

Little comparative information on the restriction of fungal growth by culture media is available. This is because few studies employ more than one culture medium and those that do usually use several methods each with its own culture medium. For the more frequently occurring species of fungi which were restricted in occurrence by media but not temperature, e.g. Acremonium persicinum, Paecilomyces marquandii, Verticillium nigrescens, this effect may be due to the culture medium. For the less frequently occurring fungi which tended to be restricted by both media and temperature, the cause is less certain. The pattern of restriction may be due to chance distribution of infrequent propagules during dilution plating.

Other possible explanations of growth restriction by certain media may also be valid, in part. Since not all colonies appearing on dilution plates were isolated, and more colonies were isolated from some media than others, it is probable some species were actually present but not isolated. This is especially relevent for rare species or those fungi most infrequently isolated. Also the recovery rate from storage was poorer for some media than others. While no accurate record was kept of this, no doubt some fungi were not recorded on particular media because of this factor.

Wohlrab and Tuveson (1965) recorded differences in fungi iso-

lated from Indiana dune soil using a series of modified Czapek-Dox media. These differences were primarily in the frequency of isolation of fungi isolated rather than differences in the species of fungi isolated. Chesters (1948) and Sewell (1959 c) noted that changes in the medium in soil immersion tubes affected the complement of fungal species isolated from soil. Sewell (1959 a, 1959 b) observed that with the exception of a single species, this effect was not observed when applied to soil plates.

Dickinson and Pugh (1965) used cellulose agar medium and mud extract agar medium for the isolation of fungi from salt marsh muds but noted only minor differences in the species recorded on these media. However, these media are similar in nature unlike the media used during this study.

This study is the only research on the occurrence and distribution of fungi from undisturbed natural Manitoba soils since the pioneer studies conducted by G. R. Bisby, N. James and M. Timonin in the 1930's. The unique nature of the beach ridge and marsh habitats, combined with a comprehensive methodology, have produced valuable new information on the occurrence and distribution of microfungi in Manitoba. The recovery of sixty-five species of fungi previously unreported in Manitoba soils, and eleven new species or variants of species, attests to this study's success. A wide range of habitats are available for similar studies in Manitoba, including a number of interesting aquatic habitats within Delta Marsh. Mycological studies of these habitats could produce results to complement the information obtained from this, and other, research on the microfungi of Manitoba soils.

APPENDIX A

Sampling Schedule

Beach Ridge - Site A, Delta Marsh, Manitoba

Week Number	Sub-Plot Sampled in Each Quadrant
1	1
2	3
3	6
4	8
5	9
6	11
7	14
8	16
9	2
10	4
11	5
12	7
13	10
14	12
15	13
16	15

Sampling Pattern - Marsh Site - Site B, Delta Marsh, Manitoba

Week Number	Sampling Pattern							
	Quadrant A		Quadrant B		Quadrant C		Quadrant D	
	Sector Number	Template Compartment	Sector Number	Template Compartment	Sector Number	Template Compartment	Sector Number	Template Compartment
1	A_1	1	B_1	2	C_1	3	D_1	4
2	A_1	4	B_1	1	C_1	2	D_1	3
3	A_1	3	B_1	4	C_1	1	D_1	2
4	A_1	2	B_1	3	C_1	4	D_1	1
5	A_2	1	B_2	2	C_2	3	D_2	4
6	A_2	4	B_2	1	C_2	2	D_2	3
7	A_2	3	B_2	4	C_2	1	D_2	2
8	A_2	2	B_2	3	C_2	4	D_2	1
9	A_3	1	B_3	2	C_3	3	D_3	4
10	A_3	4	B_3	1	C_3	2	D_3	3
11	A_3	3	B_3	4	C_3	1	D_3	2
12	A_3	2	B_3	3	C_3	4	D_3	1
13	A_4	1	B_4	2	C_4	3	D_4	4
14	A_4	4	B_4	1	C_4	2	D_4	3
15	A_4	3	B_4	4	C_4	1	D_4	2
16	A_4	2	B_4	3	C_4	4	D_4	1

APPENDIX B

CULTURE MEDIA

1. Litmans Crystal Violet Agar (LCV)

10 g glucose
10 g peptone
15 g Bacto-oxgall
10 mg crystal violet
20 g agar
1000 ml distilled water
10 mg streptomycin sulfate

Add all ingredients, except streptomycin sulfate, to distilled water; autoclave for 15 minutes at 10-12 lb/in^2. Allow to cool to approximately 50° C; add 4 ml of sterile streptomycin sulfate solution (2.5 g/1000 ml H_2O).

2. Soil Extract Agar (SEA)

100 ml soil extract
1 g glucose
0.5 g K_2HPO_4
15 g Bacto-oxgall
20 g agar
860 ml tap water
50 mg streptomycin sulfate
50 mg chloramphenicol

Prepare soil extract. (Add 1000 g soil to 1200 ml tap water; autoclave for 30 minutes at 15 lb/in^2. Filter soil solution through cheesecloth-covered cotton wool and adjust volume to 1000 ml.) Add all ingredients except streptomycin sulfate and chloramphenicol to tap water; autoclave 15 minutes at 15 lb/in^2. Allow culture medium to cool to approximately 50° C; add 20 ml each of sterile streptomycin sulfate solution (2.5 g/1000 ml H_2O) and sterile chloramphenicol solution (2.5 g/1000 ml H_2O).

3. Ohio Agricultural Experimental Station Agar (OAES)

5 g glucose
2 g yeast extract
1 g $NaNO_3$
0.5 g $MgSO_4$ $7H_2O$
1 g KH_2PO_4
1 g Bacto-oxgall
1 g sodium propionate
20 g agar
960 ml distilled water
50 mg streptomycin sulfate
50 mg chloramphenicol

Add all ingredients except streptomycin sulfate and chloramphenicol to distilled water; autoclave 20 minutes at 12 lb/in^2. Allow culture medium to cool to approximately 50° C; add 20 ml each of sterile streptomycin sulfate solution (2.5 g/1000 ml H_2O) and sterile chloramphenicol solution (2.5 g/1000 ml H_2O).

4. Potato Dextrose Agar (PDA)

200 g potatoes
1000 ml distilled water
20 g dextrose
15 g Bacto-oxgall
20 g agar
50 mg streptomycin sulfate
50 mg chloramphenicol

Wash and cube potatoes; place in 1000 ml distilled water and autoclave 10 minutes at 15 lb/in^2. Strain potato water through cheesecloth; adjust volume to 960 ml. Add dextrose, oxgall and agar; autoclave 15 minutes at 15 lb/in^2. Allow culture medium to cool to approximately 50° C; aseptically add 20 ml each of sterile streptomycin sulfate solution (2.5 g/1000 ml H_2O) and sterile chloramphenicol solution (2.5 g/1000 ml H_2O).

5. Potato Carrot Agar (PCA)

20 g carrot
20 g potato
20 g agar
1000 ml distilled water

Place diced carrot and potato in distilled water; autoclave 10 minutes at 15 lb/in^2. Strain carrot-potato water through cheesecloth; adjust volume to 1000 ml. Add agar and autoclave for 15 minutes at 15 lb/in^2.

APPENDIX C

CULTURE CODING SYSTEM

Cultures isolated during this study were coded so that the "history" of the isolate could be determined at a glance. The coding system included the following parameters:

1. Origin of Soil Sample

   (a) soil sample site

Sample Site	Code Symbol
beach ridge	R
marsh	P

   (b) soil fraction

Soil Fraction	Code Symbol
0-10 cm	1
10-20 cm	2
20-30 cm	3

The soil fraction symbol appears as a subscript of the site symbol. e.g. R_1

2. Incubation Conditions

   (a) culture medium

Culture Medium	Code Symbol
Litmans Crystal Violet Agar (LCV)	I
Soil Extract Agar (SEA)	II
Ohio Agricultural Experimental Station Agar (OAES)	III
Potato Dextrose Agar (PDA)	IV

2. (continued)

(b) incubation temperature

Incubation Temperature	Code Symbol
10^{o} C	1
15^{o} C	2
20^{o} C	3
25^{o} C	4

The culture medium symbol follows the site and soil fraction symbols; the incubation temperature symbol appears as a subscript of the culture medium symbol. e.g. $R_1 - I_1$

3. Washed Soil Dilution Plating

(a) soil wash water dilution factor

Dilution Factor	Code Symbol
1:1,000	3
1:10,000	4
1:100,000	5
1:1,000,000	6

(b) washed soil

washed soil - code symbol - S

The symbol for the wash water dilution or washed soil appears as a superscript of the culture medium symbol. e.g. $R_1 - I_1^S$

4. Isolate Accession Number

Isolates were numbered consecutively from one after they had been isolated and sorted. The accession number appears last in the culture coding system. e.g. $R_1 - I_1^S - 1$

APPENDIX D

DEVELOPMENT SCHEDULES

A. Film Development Schedule (Kodak Panatomic-X ASA 32)

1. Kodak D-76* developer (1 part D-76:1 part H_2O) at 20° C -
   9 minutes
2. Stop bath (48 ml 28% acetic acid:1000 ml H_2O) -
   30 seconds
3. Edwals Quik Fix - (73 ml concentrate:11 ml hardener:
   516 ml H_2O) -
   2 minutes
4. Wash in running water -
   1 minute
5. Edwals Hypo Eliminator - (50 ml concentrate:750 ml H_2O) -
   1½ minutes
6. Wash in running water -
   10 minutes
7. Rinse in Kodak Photo Flo - 200 (1 part concentrate:200 parts H_2O)
8. Dry in dust free place

B. Paper Development Schedule (Kodak Polycontrast F - Single Weight)

1. Kodak D-72* developer (1 part D-72:2 parts H_2O) -
   2 minutes
2. Stop bath - (48 ml 28% acetic acid and 100 ml H_2O) -
   15 seconds
3. Edwals Quick Fix - (400 ml concentrate:1800 ml H_2O:
   10 ml hardener) -
   5 minutes

B. (continued)

4. Hypo Eliminator (2% sodium sulfite) -

   4 minutes

5. Wash cold water -

   10 minutes

6. Soak in Pako Pakosol (15 ml concentrate:1000 ml H_2O) -

   5 minutes

7. Dry and gloss prints on ferroplate dryer

* D-76 Developer

water (50° C) - 750 ml

dissolve one at a time -

Kodak Elon Developing Agent - 2.0 g

Sodium Sulfite (Na_2SO_3) - 100 g

Kodak Hydroquinone - 5.0 g

Borax ($Na_2B_4O_7.10\ H_2O$) - 2.0 g

adjust volume to 1000 ml

** D-72 Developer

water (50°C) - 500 ml

dissolve one at a time -

Kodak Elon Developing Agent - 2.0 g

Sodium Sulfite (Na_2SO_3) - 45.0 g

Kodak Hydroquinone - 12.0 g

Sodium Carbonate ($Na_2CO_3.H_2O$) - 80 g

Potassium Bromide (KBr) - 2.0 g

adjust volume to 1000 ml

APPENDIX E

TABLE I

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Litmans Crystal Violet Medium at 10° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Chrysosporium pannorum	38,400	168	40,800	84	16,849		96,301
Cylindrocarpon tax. sp. 4		140	2,400	28	4,814		7,382
Doratomyces nanus			28				28
Fusarium tabacinum	2,400						2,400
F. tricinctum		56					56
Fusarium sp.		84				56	140
Kernia pachypleura		112	7,200	112			7,424
Penicillium brevi-compactum		56					56
P. citrinum	2,400	56		140		28	2,624
Penicillium sp.		28	2,400				2,428
Phycomycetes						56	56
Volutella ciliata				28			28
unidentified cultures	14,400	22	28,800	308	60,175	280	104,187
	57,600	924	81,628	12,560	81,838	420	
	58,524		94,188		82,258		223,110

TABLE II

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Litmans Crystal Violet Medium at 15° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Acremonium strictum	4,800	28			4,814		9,642
Beauveria bassiana	2,400				4,814		7,214
Chrysosporium pannorum	16,800		26,400	28	45,733	56	89,017
Cylindrocarpon tax. sp. 4			2,400			28	2,428
Fusarium oxysporum				28			28
F. tabacinum	7,200				2,407	28	9,635
F. solani				28			28
Fusarium sp.		84		56	2,407	56	2,603
Kernia pachypleura	14,400		12,000	112	48,140	28	74,680
Paecilomyces farinosus			2,400		4,814		7,214
Penicillium brevi-compactum					7,221		7,221
Penicillium cf. canescens	2,400						2,400
Penicillium cf. citrinum	2,400			84		28	2,512
Penicillium cf. damascenum			4,800				4,800
P. janthinellum			2,400				2,400
P. nalgiovense	2,400	84	2,400				4,884
Penicillium spp.		112		28	2,407	84	2,631
Phycomycetes		28	2,400				2,428
unidentified cultures	19,200	112	40,800	168	48,140	56	108,476
	72,000	448	96,000	532	170,897	364	
	72,448		96,532		171,261		340,241

TABLE III

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Litmans Crystal Violet Medium at 20° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Acremonium crotocinigenum					4,814		4,814
Ascodesmis sphaerospora					2,407		2,407
Chrysosporium pannorum	7,200		12,000		9,628		28,828
Cladosporium sp.					2,407		2,407
Cylindrocarpon tax. sp. 4			12,000	56	2,407		14,463
Doratomyces nanus	4,800		4,800				9,600
Fusarium graminearum		56		56		56	168
F. lateritium		56	4,800			56	4,912
F. semitectum				28			28
F. tabacinum		56					56
Gliocladium catenulatum		28					28
Myrothecium roridum			2,400				2,400
Paecilomyces farinosus			9,600				9,600
Paecilomyces marquandii			14,400		7,221		21,621
Penicillium brevi-compactum		56	4,800	28	2,407		7,291
Penicillium cf. canescens					2,407		2,407
Penicillium cf. citrinum		56	2,400				2,456
Penicillium cf. damascenum	2,400	28	7,200	28	16,849		26,505
Penicillium roseo-purpureum			4,800				4,800
Penicillium spp.	2,400	140	16,800	28	4,814	28	24,210
Phycomycetes		28	2,400	28	4,814		7,270
Sphaeropsidales	4,800	196	4,800	28	9,628		19,452
Trichoderma hamatum		56			4,814	28	4,898
T. harzianum		28				28	56
Unidentified cultures	14,400	280	9,600	252	45,733	140	70,405
	36,000	1,064	112,800	532	120,350	336	
	37,064		113,332		120,686		271,082

TABLE IV

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Litmans Crystal Violet Medium at 25° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Alternaria alternata	+						
Chrysosporium pannorum			2,400				2,400
Cylindrocarpon tax. sp. 4		28					28
Fusarium graminearum		56					56
F. solani			2,400		2,407		4,807
Mortierella alpina		28	2,400		2,407		4,835
Mycelia Sterilia	2,400						2,400
Myrothecium roridum	2,400				+		2,400
Paecilomyces marquandii			4,800				4,800
Penicillium brevi-compactum		56	2,400				2,456
Penicillium cf. *canescens*		28					28
Penicillium cf. *citrinum*	2,400		2,400		2,407		7,207
Penicillium cf. *damascenum*		28	2,400				2,428
Penicillium vinaceum			4,800				4,800
Penicillium spp.	7,200	168	9,600		2,407		19,375
Sphaeropsidales	7,200	168	16,800		2,407		26,575
Trichoderma harzianum	2,400	140					2,540
Taxonomic genus #1	2,400				+		2,400
Volutella sp.					2,407		2,407
unidentified cultures	14,400	56	2,400		2,407		19,263
	40,800	756	52,800	NIL	16,849	NIL	
	41,556		52,800		16,849		111,205

\+ Occurrence noted, no propagule data.

TABLE V

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Soil Extract Agar Medium at 10° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Chrysosporium pannorum	4,800		2,400				7,200
Doratomyces nanus	4,800		4,800	28			9,628
Mycelia Sterilia	12,000		4,800		+		16,800
Penicillium brevi-compactum	9,600		14,400	84			24,084
Phycomycetes		28		28			56
Sphaerospridales	9,600		4,800		+		14,400
unidentified cultures	16,800	196	36,000	336		364	53,696
	57,600	224	67,200	476		364	
	57,824		67,676		364		125,864

\+ Occurrence noted, no propagule data.

TABLE VI

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Soil Extract Agar Medium at 15° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Alternaria alternata					2,407	28	2,435
Chrysosporium pannorum	4,800		4,800		2,407		12,007
Cylindrocarpon sp.	2,400						2,400
Mortierella sp.		28		56			84
Mycelia Sterilia	7,200						7,200
Paecilomyces farinosus					2,407		2,407
Penicillium brevi-compactum			4,800				4,800
P. citrinum	4,800		2,400	56	2,407		9,663
P. cf. *damascenum*	2,400				7,221		9,621
Phialophora fastigiata	7,200		2,400				9,600
Sphaeropsidales	9,600	84	9,600	28	19,256		38,568
Trichoderma hamatum		56	12,000	56		112	12,224
Verticillium lecanii			2,400		2,407		4,807
unidentified cultures	16,800	112	28,800	252	40,919	196	87,079
	19,200	196	48,000	364	52,954	308	
	55,480		67,648		79,767		202,895

TABLE VII

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Soil Extract Agar Medium at 20° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Acremonium strictum	2,400				2,407		4,807
Alternaria alternata			4,800			84	4,996
Fusarium tabacinum			2,400		2,407	56	4,863
Fusarium spp.			2,400	112	7,221	28	9,761
Gliocladium catenulatum	2,400	364	4,800	140		84	7,788
G. roseum				28			28
Mycelia Sterilia	7,200						7,200
Paecilomyces farinosus	2,400	84	9,600		2,407	28	14,519
Penicillium brevi-compactum	4,800		14,400	28	4,814		24,042
Penicillium cf. damascenum	2,400						2,400
P. nigricans				28			28
Penicillium sp.					2,407		2,407
Phycomycetes				28		28	56
Rhinocladiella mansonii	2,400						2,400
Sphaeropsidales	14,400					28	14,428
Trichoderma hamatum			2,400		2,407	28	4,835
T. harzianum			2,400				2,400
Verticillium nigrescens			9,600				9,600
V. tenerum		56		56			112
Verticillium tax. sp. 1	7,200		2,400				9,600
Volutella ciliata					2,407		2,407
unidentified cultures	24,000	0	14,400	252	14,442	364	31,858
	48,000	616	69,600	672	40,919	728	
	48,616		70,272		41,647		160,535

TABLE VIII

Fungal Population Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Soil Extract Agar Medium at 25° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Acremonium crotocinigenum			7,200				7,200
Acremonium sp.			+				
Chrysosporium pannorum	7,200				2,407		9,607
Cylindrocarpon tax. sp. 4			2,400				2,400
Fusarium tabacinum			2,400				2,400
F. tricinctum			+			28	28
Gliocladium catenulatum			9,600	140		56	9,796
Mortierella alpina	2,400		12,000				14,400
Mycelia Sterilia	14,400		4,800		+		19,200
Paecilomyces farinosus	7,200				2,407		9,607
P. marquandii	2,400		2,400				4,800
Penicillium brevi-compactum	+	28					28
Penicillium cf. damascenum	9,600		+		4,814	28	14,442
P. expansum			+				
P. notatum			+				
P. roseo-purpureum			2,400				2,400
Penicillium spp.			16,800				16,800
Phialophora malorum			+				
Phycomycetes	2,400	28				56	2,484
Sphaeropsidales	19,200	168	21,600	56	4,814	168	46,006
Stachybotrys cf. atra						28	28
Streptomyces sp.			+				
Trichoderma hamatum			4,800		2,407		7,207
Trichoderma harzianum					21,663		21,663
Verticillium tenerum			2,400				2,400
Volutella ciliata					2,407		2,407
unidentified cultures		168	4,800	56		112	5,136
	64,800	392	93,600	252	40,919	476	
	65,192		93,852		41,395		200,439

\+ Occurrence noted, no propagule data.

TABLE IX

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Ohio Agricultural Experimental Station Medium at 10° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Acremonium strictum			4,800				4,800
Beauveria bassiana			2,400				2,400
Chrysosporium pannorum	9,600		16,800	56	14,442	56	40,954
Cladosporium sp.			2,400				2,400
Cylindrocarpon tax. sp. 4	2,400		2,400	56	9,628		14,484
Fusarium tabacinum	4,800						4,800
F. tricinctum			4,800	84	4,814	56	9,754
Fusarium spp.	2,400						2,400
Mortierella hyalina					2,407	28	2,435
Mycelia Sterilia	2,400						2,400
Paecilomyces marquandii	4,800		2,400				7,200
Penicillium brevi-compactum			7,200				7,200
Penicillium cf. canescens	2,400						2,400
Penicillium claviforme				28			28
P. citrinum			4,800				4,800
Penicillium cf. damascenum			4,800				4,800
P. expansum		28	4,800		16,849		21,677
P. janthinellum			2,400				2,400
P. nalgiovense			4,800				4,800
P. roseo-purpureum	4,800		4,800				9,600
Penicillium spp.	9,600	56	4,800				14,456
Phialophora fastigiata			2,400				2,400
Phycomycetes			2,400	28	2,407	28	4,863
Sphaeropsidales	2,400	28	43,200		4,814		50,442
Trichoderma hamatum	4,800		2,400	28	4,814		12,042
Trichoderma polysporum		28					28
Verticillium lecanii					4,814		4,814
Volutella ciliata	4,800		2,400	28	2,407	28	9,663
unidentified cultures	4,800	336		112	12,035	84	17,367
	60,000	476	127,200	420	79,431	280	
	60,476		127,620		79,711		267,807

TABLE X

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Ohio Agricultural Experimental Station Medium at 15° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Acremonium sclerotigenum	2,400						2,400
Chaetomium sp.			2,400				2,400
Chrysosporium pannorum	7,200		7,200				14,400
Cladosporium spp.	12,000						12,000
Cylindrocarpon tax. sp. 4			7,200				7,200
Fusarium spp.		84		56	+		140
Gliocladium catenulatum	7,200	56	19,200	28	+		26,484
Hormiactus alba			2,400				2,400
Mycelia Sterilia	2,400		4,800		+		7,200
Myrothecium roridum	9,600						9,600
Paecilomyces farinosus	4,800		7,200		+		12,000
Paecilomyces marquandii			7,200		+		7,200
Paecilomyces sp.			2,400				2,400
Penicillium brevi-compactum	2,400				+		2,400
Penicillium cf. *damascenum*		56	24,000				24,056
Penicillium nalgiovense	4,800						4,800
Penicillium spp.			2,400				2,400
Sphaeropsidales			4,800				4,800
Trichoderma harzianum						28	28
Ulocladium atrum			+				
Wardomyces anomalus	+						
unidentified cultures	24,000	56	4,800	270		27	29,153
	76,800	252	96,000	354		55	
	77,052		96,354		55		173,461

\+ Occurrence noted, no propagule data.

TABLE XI

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Ohio Agricultural Experimental Station Medium at 20° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Acremonium crotocinigenum						28	28
Cylindrocarpon tax. sp. 1	2,400		4,800		7,221		14,421
Cylindrocarpon tax. sp. 2	2,400						2,400
Fusarium tabacinum			9,600				9,600
F. tricinctum		140		112		84	336
Gliocladium catenulatum		28		56		84	168
G. roseum		28					28
Paecilomyces farinosus	9,600	28	2,400		4,814		16,842
P. marquandii	2,400						2,400
Penicillium brevi-compactum			7,200				7,200
Penicillium cf. canescens	2,400		7,200		7,221		16,821
Penicillium roseo-purpureum			4,800				4,800
Penicillium spp.	16,800	28	9,600		7,221	28	33,677
Phoma fimeti		56			4,814		4,870
P. glomerata					7,221		7,221
Phycomycetes				28			28
Pyrenochaeta acicola	4,800				2,407		7,207
Pyrenochaeta acicola	2,400				2,407		4,807
Pyrenochaeta tax. sp. 1						28	28
Trichoderma hamatum	24,000				2,407	56	26,463
T. harzianum		84		28	7,221	28	7,361
unidentified cultures	2,400	168	19,200	28	28,884	252	50,932
	69,600	560	64,800	252	81,838	588	
	70,160		65,052		82,426		217,638

TABLE XII

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Ohio Agricultural Experimental Station Medium at 25° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Acremonium crotocinigenum	2,400						2,400
Arthroderma curreyi (con. state)					+		
Beauveria effusa	2,400				4,814		7,214
Chrysosporium pannorum	4,800		9,600		7,221		21,621
Cylindrocarpon tax. sp. 4	4,800						4,800
Fusarium tabacinum	+						
Gliocladium catenulatum			4,800				4,800
Mycelia Sterilia					+		
Paecilomyces farinosus					2,407		2,407
P. marquandii	2,400						2,400
Penicillium cf. *canescens*			7,200		7,221		14,421
Penicillium citrinum			2,400		2,407		4,807
Penicillium cf. *damascenum*	4,800				4,814		9,614
Penicillium cf. *jensenii*	7,200		4,800				12,000
Penicillium nalgiovense			2,400				2,400
Penicillium spp.	2,400	28	9,600		12,035		24,063
Penziza ostracoderma (con. state)					2,407		2,407
Phycomycetes				56	2,407	28	2,491
Rhinocladiella mansonii	+				+		
Shaeropsidales	4,800		38,400		60,175		103,375
Trichoderma hamatum	4,800	28	19,200		2,407		26,435
T. harzianum	7,200		9,600				16,800
unidentified cultures	9,600	28	4,800		7,221	28	21,677
	57,600	84	112,800	56	115,536	56	
	57,684		112,856		115,592		286,132

\+ Occurrence noted, no propagule data.

TABLE XIII

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Potato Dextrose Agar Medium at 15° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Chrysosporium pannorum	4,800		7,200				12,000
Fusarium solani		28					28
Gliocladium catenulatum			7,200		4,814		12,014
Myrothecium roridum					2,407		2,407
Paecilomyces farinosus					2,407		2,407
Penicillium cf. *canescens*			7,200				7,200
P. rolfsii	9,600						9,600
P. steckii			4,800				4,800
Penicillium spp.	4,800		14,400				19,200
Sphaeropsidales	9,600		7,200				16,800
Trichoderma hamatum	4,800				9,628		14,428
Trichoderma harzianum	9,600	56	14,400		7,221		31,277
unidentified cultures	33,600	280	45,600	196	28,884		108,560
	76,800	364	108,000	196	55,361	0	
	77,164		108,196		55,361		240,721

TABLE XIV

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Potato Dextrose Agar Medium at 20° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Chrysosporium sp.			2,400				2,400
Cylindrocarpon tax. sp. 4	2,400						2,400
Fusarium arthrosporioides		56		56			112
F. oxysporum	7,200						7,200
F. poae	2,400						2,400
Gliocladium roseum		84	9,600	28			9,712
Paecilomyces farinosus	2,400		16,800		2,407		21,607
Penicillium brevi-compactum	2,400		4,800		2,407		9,607
Penicillium cf. *damascenum*	7,200				7,221		14,421
Penicillium cf. *jensenii*	2,400		2,400		2,407		7,207
P. nigricans	2,400						2,400
P. steckii			12,000		2,407		14,407
Penicillium spp.	2,400		4,800	56	24,070		31,326
Phycomycetes	+	28					28
Sphaeropsidales	2,400		12,000		16,849		31,249
Trichoderma hamatum	2,400				2,407		4,807
T. harzianum	+			28			28
unidentified cultures	24,000	336	19,200	168	19,256		62,960
	26,400	336	38,400	168	24,070	0	
	60,504		84,336		79,431		224,271

\+ Occurrence noted, no propagule data.

TABLE XV

Fungal Propagule Numbers from Lake Ridge Soil (Delta Marsh, Manitoba)
Fungi Selected by Potato Dextrose Agar Medium at 25° C

	Number of Propagative Units Per Gram Dry Weight of Soil						
	0-10 cm		10-20 cm		20-30 cm		
Name	Wash	Soil	Wash	Soil	Wash	Soil	TOTAL
Acremonium crotocinigenum	2,400						2,400
Beauveria effusa			2,299		+		2,400
Chrysosporium pannorum	4,800				+		4,800
Cylindrocarpon sp.					+		
Doratomyces nanus					+		
Fusarium arthrosporiodes		28					28
Gliocladium catenulatum		28					28
Mycelia Sterilia	14,400		2,400		+		16,800
Myrothecium roridum	4,800		2,400				7,200
Paecilomyces farinosus	2,400				2,407		4,807
Penicillium cf. damascenum	9,600		9,600		2,407		21,607
Penicillium cf. jensenii	9,600		7,200		4,814		21,614
P. nalgiovense	2,400						2,400
P. oxalicum	2,400		2,400				4,800
P. roseo-purpureum	16,800		2,400		2,407		21,607
P. steckii	2,400		2,400		2,407		7,207
Penicillium spp.	2,400		7,200				9,600
Sphaeropsidales	7,200		19,200		7,221		33,621
Trichoderma hamatum		28	57,600		50,547		108,175
T. harzianum					2,407		2,407
Trichosporon sp.			+				
Verticillium lamellicola			+				
Volutella ciliata	+				+		
unidentified cultures	12,000	225	2,400	308	9,628		24,560
	93,600	308	120,000	308	91,466	0	
	93,908		120,308		91,466		305,682

\+ Occurrence noted, no propagule data

TABLE XVI

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Litmans Crystal Violet Medium at 10° C

Name	Number of Propagative Units Per Gram Dry Weight of Soil 0-10 cm		
	Wash	Soil	TOTAL
Botryotrichum piluliferum	300	3,135	3,435
Chrysosporium pannorum	300		300
Cylindrocarpon tax. sp. 3	300	12,540	12,840
Doratomyces nanus	8,700	7,315	16,015
Paecilomyces farinosus		1,045	1,045
Penicillium cf. damascenum	2,100	8,360	10,460
Penicillium nigricans	300	7,315	7,615
Phycomycetes	1,200	1,045	2,245
Trichoderma viride	900	3,135	4,035
Unidentified cultures		1,045	1,045
	14,100	44,935	59,035

TABLE XVII

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Litmans Crystal Violet Medium at 15° C

Name	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
	Wash	Soil	TOTAL
Botryotrichum piluliferum	300	3,135	3,435
Chaetomium spp.		2,090	2,090
Chrysosporium pannorum	600		600
Cylindrocarpon tax. sp. 3		1,045	1,045
Doratomyces nanus	6,900	6,270	13,170
D. putredinis	300	1,045	1,345
Fusarium tabacinum		2,090	2,090
Penicillium cf. canescens		3,135	3,135
Penicillium cf. damascenum	3,300	6,270	9,570
Penicillium nigricans	3,600	4,180	7,780
Penicillium sp.	300		300
Phycomycetes	300	4,180	4,480
Taxonomic genus #1		1,045	1,045
Trichoderma harzianum	1,200		1,200
T. viride	300	1,045	1,345
Unidentified cultures		1,045	1,045
	17,100	42,845	59,945

TABLE XVIII

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Litmans Crystal Violet Medium at 20° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Cylindrocarpon tax. sp. 3	600	4,180	4,780
Doratomyces nanus	3,300	10,450	13,750
Fusarium tabacinum		1,045	1,045
Paecilomyces sp.		1,045	1,045
Penicillium cf. *damascenum*	2,400	15,675	18,075
P. nigricans	2,400	4,180	6,580
Phycomycetes	1,200	1,045	2,245
Trichoderma harzianum	300	1,045	1,345
Verticillium lecanii	9,600	37,620	47,220
Unidentified cultures		2,090	2,090
	10,200	44,935	55,135

TABLE XIX

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Litmans Crystal Violet Medium at 25° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Botryotrichum piluliferum		3,135	3,135
Cylindrocarpon tax. sp. 3	1,500	8,360	9,860
Doratomyces nanus	2,400	8,360	10,760
Fusarium graminearum	300		300
F. tabacinum		2,090	2,090
Mariannaea elegans var. elegans		2,090	2,090
Paecilomyces sp.	8,700	41,800	50,500
Penicillium cf. canescens	300		300
Penicillium cf. damascenum	3,300	15,675	18,975
Penicillium nigricans	1,200	11,495	12,695
Phycomycetes	600	4,180	4,780
Rhinocladiella mansonii	300		300
Trichoderma harzianum	300		300
Unidentified cultures	300	2,090	2,390
	11,100	59,565	70,665

TABLE XX

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Soil Extract Agar Medium at 10° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Acremonium persicinum		1,045	1,045
Botryotrichum piluliferum		2,090	2,090
Botrytis cinerea		1,045	1,045
Chrysosporium pannorum	8,400	3,135	11,535
Cylindrocarpon tax. sp. 5	300	5,225	5,525
Doratomyces nanus	7,200	33,440	40,640
D. putredinis	1,500		1,500
Fusarium graminearum		1,045	1,045
F. sporotrichoides	300		300
F. tabacinum		1,045	1,045
Geomyces vulgaris	12,600	12,540	25,140
Gliomastix cerealis	300		300
Mortierella sp.		4,180	4,180
Paecilomyces marquandii	900		900
Penicillium cf. *canescens*	1,500	6,270	7,770
Penicillium cf. *damascenum*	600	2,090	2,690
Penicillium nigricans	300	3,135	3,435
Phycomycetes		2,090	2,090
Trichoderma viride		4,180	4,180
Unidentified cultures	2,400	4,180	6,580
	24,000	74,195	98,195

TABLE XXI

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Soil Extract Agar Medium at 15° C

Name	Number of Propagative Units Per Gram Dry Weight of Soil 0-10 cm		
	Wash	Soil	TOTAL
Chrysosporium pannorum		4,180	4,180
Cylindrocarpon tax. sp. 5		7,315	7,315
Doratomyces nanus	11,400	10,450	21,850
D. putredinis	600		600
Fusarium graminearum	300	3,135	3,435
F. sporotrichoides	300	1,045	1,345
F. tabacinum		1,045	1,045
Paecilomyces marquandii	1,800	3,135	4,935
Penicillium cf. *damascenum*	900	6,270	7,170
P. expansum	600		600
P. nigricans	3,000	7,313	10,313
Trichoderma viride	600	8,360	8,960
Verticillium nigrescens	300		300
Unidentified cultures	600	1,045	1,645
	20,400	53,293	73,693

TABLE XXII

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Soil Extract Agar Medium at 20° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Acremonium strictum		1,045	1,045
Botryotrichum piluliferum		5,225	5,225
Chrysosporium pannorum	600	1,045	1,645
Cladosporium sp.		3,135	3,135
Cylindrocarpon tax. sp. 3		14,630	14,630
Cylindrocarpon tax. sp. 5	900		900
Doratomyces nanus	6,900	3,135	10,035
Fusarium graminearum	1,200		1,200
F. tabacinum	600	7,315	7,915
F. tricinctum	600	1,045	1,645
Myrothecium roridum		1,045	1,045
Paecilomyces marquandii	600	2,090	2,690
Penicillium cf. jensenii		3,135	3,135
Penicillium nigricans	2,700	12,540	15,240
Penicillium spp.	3,000	6,270	9,270
Phycomycete		1,045	1,045
Rhinocladiella cf. anceps	600		600
Sporotrichum epigaeum var. terrestre	300	3,135	3,435
Taxonomic genus #1		2,090	2,090
Trichoderma hamatum	300	1,045	1,345
T. viride	600	2,090	2,690
Verticillium lamellicola		2,090	2,090
Verticillium lecanii		3,135	3,135
V. nigrescens		1,045	1,045
Unidentified cultures		4,180	4,180
	18,900	81,510	100,410

TABLE XXIII

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Soil Extract Agar Medium at 25° C

Name	Number of Propagative Units Per Gram Dry Weight of Soil 0-10 cm		
	Wash	Soil	TOTAL
Acremonium persicenum		2,090	2,090
A. strictum	300	2,090	2,390
Botryotrichum piluliferum	600		600
Chrysosporium pannorum	900	2,090	2,990
Cylindrocarpon tax. sp. 3		1,045	1,045
Cylindrocarpon Tax. sp. 5		1,045	1,045
Dactylaria scaphoides		1,045	1,045
Doratomyces nanus	6,000	8,360	14,360
Fusarium graminearum	1,200		1,200
Fusarium tabacinum	300	1,045	1,345
Mariannaea elegans var. elegans		1,045	1,045
Mortierella alpina	3,300		3,300
Paecilomyces marquandii	1,800	1,045	2,845
Penicillium cf. damascenum	2,100	1,045	3,145
Penicillium cf. jensenii	300		300
Penicillium nigricans	3,000	2,090	5,090
Penicillium spp.		9,405	9,405
Sporotrichum epigaeum var. terrestre		1,045	1,045
Trichoderma hamatum	300	3,135	3,435
T. harzianum	300	2,090	2,390
T. viride	600	3,135	3,735
Verticellium dahliae		1,045	1,045
V. lecanii		3,135	3,135
Unidentified cultures		4,180	4,180
	21,000	50,160	71,160

TABLE XXIV

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Ohio Agricultural Experimental Station Medium at 10° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Acremonium persicinum	900	1,045	1,945
Chrysosporium pannorum	2,400	3,135	5,535
Chrysosporium sp.	600		600
Cylindrocarpon tax. sp. 3		6,270	6,270
Doratomyces nanus	6,000	21,945	27,945
Fusarium graminearum	300	5,225	5,525
F. tabacinum	300	9,405	9,705
Fusidium cf. griseum		1,045	1,045
Penicillium cf. claviforme	1,200		1,200
Penicillium cf. damascenum	900	5,225	6,125
P. nigricans	300	3,135	3,435
P. stoloniferum		1,045	1,045
Penicillium spp.	300	4,180	4,480
Phialophora malorum	300		300
Phycomycete	900	4,180	5,080
Sphaeropsidales	300	5,225	5,525
Sporotrichum epigaeum var. terrestre	600		600
Trichoderma harzianum	600	6,270	6,870
T. viride	1,800	3,135	4,935
Trichuris spiralis	300		300
Verticillium nigrescens		1,045	1,045
Unidentified cultures	300	3,135	3,435
	18,300	84,645	102,945

TABLE XXV

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Ohio Agricultural Experimental Station Medium at 15° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Acremonium furcatum	1,200	2,090	3,290
A. persicinum	1,200	3,135	4,335
Acremonium sp.	300		300
Botryotrichum pilulliferum		2,090	2,090
Chrysosporium mediarum var. roseum	600		600
C. pannorum	3,600	2,090	5,690
Cylindrocarpon tax. sp. 3	300	12,540	12,840
Cylindrocarpon sp.	300		300
Doratomyces nanus	2,400		2,400
Fusarium graminearum	1,500	5,225	6,725
Fusarium tabacinum	1,200	2,090	3,290
Fusarium spp.	1,500		1,500
Penicillium cf. damascenum	3,300	10,450	13,750
P. frequentans	300		300
P. nigricans	600	11,495	12,095
P. stoloniferum	1,500		1,500
Penicillium sp.	300		300
Phialophora fastigiata	300		300
Plenodomus sp. nov.	300		300
Rhinocladiella mansonii		1,045	1,045
Sphaeropsidales		2,090	2,090
Sporotrichum epigaeum var. terrestre		3,135	3,135
Streptomyces sp.		1,045	1,045
Trichoderma harzianum	300	3,135	3,435
T. viride	600	1,045	1,645
Verticillium nigrescens	300	5,225	5,525
Unidentified cultures	2,100	4,180	6,280
	24,000	72,105	96,105

TABLE XXVI

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Ohio Agricultural Experimental Station Medium at 20° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Acremonium furcatum	300		300
A. persicinum		4,180	4,180
A. strictum		2,090	2,090
Alternaria alternata		1,045	1,045
Chrysosporium pannorum	600	5,225	5,825
Cylindrocarpon tax. sp. 3	300	4,180	4,480
Doratomyces nanus	6,900	8,360	15,260
Emericellopsis tax. sp. 1		1,045	1,045
Fusarium graminearum	300	3,135	3,435
Fusarium tabacinum		3,135	3,135
Fusarium spp.	4,180	4,180	4,180
Paecilomyces marquandii	300	3,135	3,435
Penicillium brevi-compactum		2,090	2,090
Penicillium cf. damascenum	300	4,180	4,480
Penicillium spp.		6,270	6,270
Phialophora sp. nov.		1,045	1,045
Phycomycetes	1,200		1,200
Trichoderma hamatum	900		900
T. harzianum	300		300
T. viride	2,400	2,090	4,490
Verticillium nigrescens	300	10,450	10,750
Verticillium tenerum		1,045	1,045
Verticillium sp.		2,090	2,090
Unidentified cultures	300	5,225	5,525
	14,400	74,195	88,095

TABLE XXVII

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Ohio Agricultural Experimental Station Medium at 25° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Acremonium persicinum	900	3,135	4,035
A. strictum	600	2,090	2,690
Botryotrichum piluliferum	300	2,090	2,390
Chrysosporium pannorum	600		600
Cylindrocarpon tax. sp. 3		12,540	12,540
Doratomyces nanus	1,500		1,500
Fusarium graminearum		3,135	3,135
Fusarium tabacinum		8,360	8,360
Fusarium sp.		1,045	1,045
Paecilomyces marquandii		7,315	7,315
Penicillium brevi-compactum		2,090	2,090
Penicillium cf. damascenum	900	9,405	10,305
Penicillium spp.	300	19,855	20,155
Phycomycetes	300	1,045	1,345
Pyrenochaeta sp.		1,045	1,045
Trichoderma hamatum		1,045	1,045
T. harzianum	2,700	2,090	4,790
T. viride	2,100	2,090	4,190
Sphaeropsidales		1,045	1,045
Verticillium nigrescens		6,270	6,270
Verticillium sp.		1,045	1,045
Unidentified cultures	300	1,045	1,345
	10,500	87,780	98,280

TABLE XXVIII

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Potato Dextrose Agar Medium at 10° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Acremonium persicinum	300		300
Chrysosporium pannorum	1,200	2,090	3,290
Cylindrocarpon tax. sp. 3		6,270	6,270
Cylindrocarpon tax. sp. 5		3,135	3,135
Doratomyces nanus	1,200	7,315	8,515
Geomyces sp.	300		300
Paecilomyces marquandii		1,045	1,045
Penicillium brevi-compactum	300	8,360	8,660
Penicillium cf. damascenum	1,800	9,405	11,205
Penicillium nigricans	600		600
Penicillium spp.	1,200	1,045	2,245
Phycomycetes		2,090	2,090
Sporothrix sp.	300		300
Trichoderma harzianum		4,180	4,180
T. viride	1,248	2,090	3,338
Verticillium nigrescens	300		300
Verticillium spp.	300	2,090	2,390
Unidentified cultures		1,045	1,045
	9,048	51,205	60,253

TABLE XXIX

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Potato Dextrose Agar Medium at 15° C

Name	Number of Propagative Units Per Gram Dry Weight of Soil 0-10 cm		
	Wash	Soil	TOTAL
Acremonium persicinum	300		300
Acremonium sp.	1,800		1,800
Arthrinium phaeospermum	300		300
Chaetomium funicolum		1,045	1,045
Chrysosporium pannorum	3,300	1,045	4,345
Cylindrocarpon tax. sp. 5 -	300		300
Doratomyces nanus	2,400	1,045	3,445
Fusarium graminearum	300	6,270	6,570
F. sporotrichoides		1,045	1,045
F. tricinctum	900		900
Fusarium sp.		1,045	1,045
Paecilomyces marquandii	600	1,045	1,645
Penicillium brevi-compactum	300		300
Penicillium cf. damascenum	300	7,315	7,615
Penicillium sp.	900		900
Phycomycetes		3,135	3,135
Sporothrix sp.	300		300
Trichoderma harzianum	600	4,180	4,780
T. viride	1,200	6,270	7,470
Verticillium nigrescens	600		600
Unidentified cultures	1,500	1,045	2,545
	15,900	34,485	50,385

TABLE XXX

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Potato Dextrose Agar Medium at 20° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
Name	Wash	Soil	TOTAL
Botryotrichum piluliferum		2,090	2,090
Chrysosporium pannorum	900	1,045	1,945
Cylindrocarpon tax. sp. 3		5,225	5,225
Doratomyces nanus	300		300
Fusarium graminearum	300	2,090	2,390
F. tabacinum	1,200		1,200
Mortierella sp.		1,045	1,045
Paecilomyces marquandii	600	6,270	6,870
Penicillium brevi-compactum	2,400	1,045	3,445
Penicillium cf. damascenum	6,900	10,450	17,350
P. nigricans	900	5,225	6,125
Penicillium spp.	900	10,450	11,350
Taxonomic genus #1		1,045	1,045
Trichoderma hamatum	300		300
T. harzianum	1,500	6,270	7,770
T. viride	600	2,090	2,690
Verticillium nigrescens		1,045	1,045
Unidentified cultures	1,600	2,090	3,690
	18,400	57,475	75,875

TABLE XXXI

Fungal Propagule Numbers from Marsh Soil (Delta Marsh, Manitoba)
Fungi Selected by Potato Dextrose Agar Medium at 25° C

	Number of Propagative Units Per Gram Dry Weight of Soil		
	0-10 cm		
	Wash	Soil	TOTAL
Chrysosporium pannorum	3,300	1,045	4,356
Cylindrocarpon tax. sp. 3	300	5,225	5,525
Doratomyces nanus	1,800	3,135	4,935
Fusarium graminearum	1,500	1,045	2,545
F. tabacinum	300	20,900	21,200
F. tricinctum		1,045	1,045
Fusarium sp.	300		300
Mariannaea elegans var. elegans		1,045	1,045
Paecilomyces marquandii	900	5,225	6,125
Penicillium cf. damascenum	300	4,180	4,480
Stachybotrys cf. atra		1,045	1,045
Trichoderma harzianum		9,405	9,405
T. viride	1,200	11,495	12,695
Verticillium nigrescens		2,090	2,090
Unidentified Cultures	3,600	4,180	7,786
	21,600	61,655	83,255

TABLE XL

Distribution of Fungi Isolated From Soil, Delta Marsh, Manitoba

Name	Beach Ridge Soil	Marsh Soil
Acremonium crotocinigenum	+	
Acremonium furcatum		+
Acremonium persicinum		+
Acremonium sclerotigenum	+	
Acremonium strictum	+	+
Acremonium sp.	+	+
Alternaria alternata	+	+
Arthrinium phaeospermum		+
Arthroderma curreyi (con. state)	+	
Ascodesmis sphaerospora	+	
Beauveria bassiana	+	
Botryotrichum piluliferum		+
Botrytis cinerea		+
Chaetomium funicolum		+
Chaetomium spp.	+	+
Chrysosporium merdarium var. roseum		+
Chrysosporium pannorum	+	+
Chrysosporium spp.	+	+
Cladosporium spp.	+	+
Cylindrocarpon tax. sp. 1	+	
Cylindrocarpon tax. sp. 2	+	
Cylindrocarpon tax. sp. 3		+
Cylindrocarpon tax. sp. 4	+	
Cylindrocarpon tax. sp. 5		+
Cylindrocarpon sp.	+	+
Dactylaria scaphoides		+
Doratomyces nanus	+	+
Doratomyces putredinis		+
Emericellopsis sp.		+
Fusarium arthrosporioides	+	

continued...

TABLE XL (continued)

Distribution of Fungi Isolated From Soil, Delta Marsh, Manitoba

Name	Beach Ridge Soil	Marsh Soil
Fusarium graminearum	+	+
Fusarium lateritium	+	
Fusarium oxysporum	+	
Fusarium poae	+	
Fusarium semitectum	+	
Fusarium solani	+	
Fusarium sporotrichioides		+
Fusarium tabacinum	+	+
Fusarium tricinctum	+	+
Fusarium spp.	+	+
Fusidium cf. *griseum*		+
Gliocladium catenulatum	+	
Gliocladium roseum	+	
Gliomastix cerealis		+
Hormiactus alba	+	
Kernia pachypleura	+	
Mariannaea elegans var. *elegans*		+
Mortierella alpina	+	+
Mortierella hyalina	+	
Mortierella spp.	+	+
Mycelia Sterilia	+	
Myrothecium roridum	+	+
Paecilomyces farinosus	+	+
Paecilomyces marquandii	+	+
Paecilomyces spp.	+	+
Penicillium brevi-compactum	+	+
Penicillium cf. *canescens*	+	+
Penicillium cf. *citrinum*	+	
Penicillium cf. *claviforme*	+	+
Penicillium cf. *damascenum*	+	+

continued...

TABLE XL (continued)

Distribution of Fungi Isolated From Soil, Delta Marsh, Manitoba

Name	Beach Ridge Soil	Marsh Soil
Penicillium expansum	+	+
Penicillium frequentans		+
Penicillium janthinellum	+	
Penicillium cf. jenseni	+	+
Penicillium nalgiovensis	+	
Penicillium nigricans	+	+
Penicillium notatum	+	
Penicillium oxalicum	+	
Penicillium rolfsii	+	
Penicillium roseo-purpureum	+	
Penicillium steckii	+	
Penicillium stoloniferum		+
Penicillium vinaceum	+	
Penicillium spp.	+	+
Peziza ostracoderma (con. state)	+	
Phialophora fastigiata	+	+
Phialophora malorum	+	+
Phialophora sp. nov.		+
Phoma fimeti	+	
Phoma glomerata	+	
Phoma sp.		
Phycomycetes	+	+
Plenodomus sp. nov.		+
Pyrenochaeta acicola	+	
Pyrenochaeta tax. sp. I	+	
Pyrenochaeta sp.		+
Rhinocladiella cf. anceps		+
Rhinocladiella mansonii	+	+
Sphaeropsidales	+	+
Sporothrix sp.		+

continued...

TABLE XL (continued)

Distribution of Fungi Isolated From Soil, Delta Marsh, Manitoba

Name	Beach Ridge Soil	Marsh Soil
Sporotrichum epigaeum var. terrestre		+
Stachybotrys cf. atra	+	+
Taxonomic genus #1	+	+
Trichoderma hamatum	+	+
Trichoderma harzianum	+	+
Trichoderma polysporum	+	
Trichoderma viride		+
Trichosporon sp.	+	
Trichurus spiralis		+
Ulocladium atrum	+	
Verticillium dahliae		+
Verticillium lamellicola	+	+
Verticillium lecanii	+	+
Verticillium nigrescens	+	+
Verticillium tenerum	+	+
Verticillium tax. sp. 1	+	
Verticillium spp.		+
Volutella ciliata	+	
Volutella sp.	+	
Wardomyces anomalus	+	

TABLE XLI

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction; Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Acremonium crotocinigenum							+	
Acremonium sclerotigenum			+					
Acremonium strictum			+	+	+			
Alternaria alternata							+	
Beauveria bassiana			+				+	
Chrysosporium pannorum	+	+	+		+	+	+	
Cladosporium spp.			+					
Cylindrocarpon tax. sp. 1					+			
Cylindrocarpon tax. sp. 2					+			
Cylindrocarpon tax. sp. 4	+	+			+		+	+
Cylindrocarpon sp.			+					
Doratomyces nanus	+				+			
Fusarium arthrosporioides						+		+
Fusarium graminearum						+		+
Fusarium lateritium						+		
Fusarium oxysporum					+			
Fusarium poae					+			
Fusarium solani				+				
Fusarium tabacinum	+					+	+	
Fusarium tricinctum		+				+		
Fusarium spp.	+	+		+				
Gliocladium catenulatum			+	+	+	+		+
Gliocladium roseum						+		
Kernia pachypleura		+	+					

continued...

TABLE XLI (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction; Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Mortierella alpina							+	+
Mortierella sp.				+				
Mycelia Sterilia	+		+		+		+	
Myrothecium roridum			+				+	
Paecilomyces farinosus			+		+	+	+	
Paecilomyces marquandii	+						+	
Penicillium brevi-compactum	+	+	+		+	+	+	+
Penicillium cf. canescens	+		+		+		+	+
Penicillium cf. citrinum	+	+	+			+	+	
Penicillium cf. damascenum			+		+	+	+	+
Penicillium expansum		+						
Penicillium cf. jensenii					+		+	
Penicillium naigiovense			+	+			+	
Penicillium nigricans					+			
Penicillium oxalicum							+	
Penicillium rolfsii			+					
Penicillium roseo-purpureum	+						+	
Penicillium steckii							+	
Phialophora fastigiata			+					
Phoma fimeti						+		
Phycomycetes		+			+	+	+	+
Pyrenochaeta acicola					+			
Pyrenochaeta spp.					+			
Rhinocladiella mansonii					+		+	

continued...

TABLE XLI (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction; Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Taxonomic genus #1							+	
Trichoderma hamatum	+		+	+	+	+	+	+
Trichoderma harzianum			+	+	+	+	+	+
Trichoderma polysporum		+						
Verticillium tenerum						+		
Verticillium tax. sp. 1					+			
Volutella ciliata	+						+	
Wardomyces anomalus			+					

TABLE XLII

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 10-20 cm Soil Fraction; Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Acremonium crotocinigenum							+	
Acremonium strictum	+							
Acremonium sp.							+	
Alternaria alternata					+			
Beauveria bassiana	+						+	
Chaetomium sp.	+							
Chrysosporium pannorum	+	+	+	+	+		+	
Chrysosporium sp.					+			
Cladosporium sp.	+							
Cylindrocarpon tax. sp. 1					+			
Cylindrocarpon tax. sp. 4	+	+	+		+	+	+	
Doratomyces nanus	+	+			+			
Fusarium arthrosporioides						+		
Fusarium graminearum						+		
Fusarium lateritium					+			
Fusarium oxysporum				+				
Fusarium solani							+	
Fusarium tabacinum				+	+		+	
Fusarium tricinctum	+	+				+	+	
Fusarium spp.				+	+	+		
Gliocladium catenulatum			+	+	+	+	+	+
Gliocladium roseum					+	+		
Hormiactus alba			+					
Kernia pachypleura	+	+	+	+				

continued...

TABLE XLII (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 10-20 cm Soil Fraction; Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Mortierella alpina							+	
Mortierella sp.				+				
Mycelia Sterilia	+		+				+	
Myrothecium roridum					+		+	
Paecilomyces farinosus			+		+			
Paecilomyces marquandii	+		+		+		+	
Paecilomyces spp.			+					
Penicillium brevi-compactum	+	+	+		+	+	+	
Penicillium cf. canescens			+		+		+	
Penicillium cf. citrinum	+	+	+	+			+	
Penicillium cf. damascenum	+		+				+	
Penicillium expansum	+						+	
Penicillium janthinellum	+		+					
Penicillium cf. jensenii					+		+	
Penicillium naigiovense	+		+				+	
Penicillium nigricans						+		
Penicillium notatum							+	
Penicillium oxalicum							+	
Penicillium roseo-purpureum	+				+		+	
Penicillium steckii			+		+		+	
Penicillium vinaceum							+	
Penicillium spp.	+		+	+	+	+	+	
Phialophora fastigiata	+		+					
Phycomycetes	+	+	+		+	+		

continued...

TABLE XLII (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 10-20 cm Soil Fraction; Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Sphaeropsidales	+		+	+	+	+	+	
Trichoderma hamatum	+	+	+	+			+	
Trichoderma harzianum			+	+			+	
Trichosporon sp.							+	
Ulocladium atrum			+					
Verticillium lamellicola							+	
Verticillium lecanii			+					
Verticillium nigrescens					+			
Verticillium tenerum						+	+	
Verticillium tax. sp. I					+			
Volutella ciliata	+	+						

TABLE XLIII

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 20-30 cm Soil Fraction; Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Acremonium crotocinigenum					+	+		
Acremonium strictum			+		+			
Alternaria alternata			+	+		+		
Arthroderma curreyi							+	
Ascodesmis sphaerospora					+			
Beauveria bassiana			+					
Chrysosporium pannorum	+	+	+	+	+		+	
Cladosporium spp.					+			
Cylindrocarpon tax. sp. I					+			
Cylindrocarpon tax. sp. 4	+			+	+			
Cylindrocarpon sp.							+	
Doratomyces nanus							+	
Fusarium graminearum						+		
Fusarium lateritium						+		
Fusarium solani							+	
Fusarium tabacinum			+	+	+	+		
Fusarium tricinctum	+	+				+		+
Fusarium spp.		+	+	+	+	+		
Gliocladium catenulatum			+			+		+
Kernia pachypleura			+	+				
Mortierella alpina							+	
Mortierella hyalina	+	+						
Mycelia Sterilia	+		+				+	
Myrothecium roridum			+				+	

continued...

TABLE XLIII (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 20-30 cm Soil Fraction; Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Paecilomyces farinosus			+		+	+	+	
Paecilomyces marquandii			+		+			
Penicillium brevi-compactum			+		+			
Penicillium cf. canescens					+		+	
Penicillium cf. citrinum		+	+	+			+	
Penicillium cf. damascenum			+		+		+	+
Penicillium expansum	+							
Penicillium cf. jensenii					+		+	
Penicillium roseo-purpureum							+	
Penicillium steckii					+		+	
Penicillium spp.		+	+	+	+	+	+	
Peziza ostracoderma (con. state)							+	
Phoma fimeti					+			
Phoma glomerata					+			
Phycomycetes	+	+			+	+	+	+
Pyrenochaeta acicola					+			
Pyrenochaeta tax. sp. I						+		
Pyrenochaeta spp.					+			
Rhinocladiella mansonii							+	
Sphaeropsidales	+		+		+	+	+	+
Stachybotrys cf. atra								+
Taxonomic genus #1							+	
Trichoderma hamatum	+		+	+	+	+	+	
Trichoderma harzianum			+	+	+	+	+	
Verticillium lecanii	+		+					
Volutella ciliata	+	+			+		+	
Volutella sp.							+	

TABLE XLIV

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction; Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Acremonium crotocinigenum					+		+	
Acremonium sclerotigenum					+			
Acremonium strictum	+	+	+					
Alternaria alternata	+							
Beauveria bassiana	+				+			
Chrysosporium pannorum	+	+	+		+		+	
Cladosporium spp.					+			
Cylindrocarpon tax. sp. 1					+			
Cylindrocarpon tax. sp. 2					+			
Cylindrocarpon tax. sp. 4		+			+		+	
Cylindrocarpon sp.			+					
Doratomyces nanus	+		+					
Fusarium arthrosporioides								+
Fusarium graminearum		+						
Fusarium lateritium		+						
Fusarium oxysporum							+	
Fusarium poae							+	
Fusarium solani								+
Fusarium tabacinum	+	+			+			
Fusarium tricinctum		+			+	+		
Fusarium sp.		+			+			
Gliocladium catenulatum		+	+	+	+	+		+
Gliocladium roseum						+		+
Kernia pachypleura	+	+						

continued...

TABLE XLIV (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil
(Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction;
Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Mortierella alpina		+						
Mortierella sp.				+				
Mycelia Sterilia	+		+		+		+	
Myrothecium roridum	+				+		+	
Paecilomyces farinosus			+	+	+	+	+	
Paecilomyces marquandii			+		+			
Penicillium brevi-compactum		+	+	+	+		+	
Penicillium cf. canescens	+	+			+		+	
Penicillium cf. citrinum	+	+	+					
Penicillium cf. damascenum	+	+	+		+		+	
Penicillium expansum						+		
Penicillium cf. jensenii					+		+	
Penicillium naigiovense	+	+			+		+	
Penicillium nigricans							+	
Penicillium oxalicum							+	
Penicillium rolfsii							+	
Penicillium roseo-purpureum					+		+	
Penicillium steckii							+	
Phialophora fastigiata			+					
Phoma fimeti						+		
Phycomycetes		+	+	+			+	+
Pyrenochaeta acicola					+			
Pyrenochaeta sp.					+			
Rhinocladiella mansonii			+		+			

continued...

TABLE XLIV (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil
(Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction;
Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Sphaeropsidales	+	+	+	+	+	+	+	+
Taxonomic genus #1	+							
Trichoderma hamatum		+		+	+	+	+	+
Trichoderma harzianum	+	+			+	+	+	+
Trichoderma polysporum						+		
Verticillium tenerum				+				
Verticillium tax. sp. 1			+					
Volutella ciliata					+		+	
Wardomyces anomalus					+			

TABLE XLV

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 10-20 cm Soil Fraction; Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Acremonium crotocinigenum			+					
Acremonium strictum					+			
Acremonium sp.	+							
Alternaria alternata			+					
Beauveria bassiana					+		+	
Chaetomium sp.					+			
Chrysosporium pannorum	+	+	+		+	+	+	
Chrysosporium sp.							+	
Cladosporium sp.					+			
Cylindrocarpon tax. sp. 1					+			
Cylindrocarpon tax. sp. 4	+	+			+	+		
Doratomyces nanus		+	+	+				
Fusarium arthrosporioides								+
Fusarium graminearum		+						
Fusarium lateritium	+							
Fusarium oxysporum		+						
Fusarium semitectum		+						
Fusarium solani	+	+						
Fusarium tabacinum			+		+			
Fusarium tricinctum			+		+	+		
Gliocladium catenulatum			+	+	+	+	+	
Gliocladium roseum				+			+	+
Hormiactus alba					+			
Kernia pachypleura	+	+						

continued...

TABLE XLV (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 10-20 cm Soil Fraction; Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Mortierella alpina	+		+					
Mortierella spp.				+				
Mycelia Sterilia	+				+		+	
Myrothecium roridum	+						+	
Paecilomyces farinosus	+		+		+		+	
Paecilomyces marquandii	+		+		+			
Paecilomyces sp.					+			
Penicillium brevi-compactum	+	+	+	+	+		+	
Penicillium cf. canescens		+			+		+	
Penicillium cf. citrinum	+	+	+	+	+			
Penicillium cf. damascenum	+	+	+		+		+	
Penicillium expansum			+		+			
Penicillium janthinellum	+				+			
Penicillium cf. jensenii					+		+	
Penicillium nalgiovense	+				+			
Penicillium nigricans					+			
Penicillium notatum			+					
Penicillium oxalicum							+	
Penicillium roseo-purpureum	+		+		+		+	
Penicillium steckii							+	
Penicillium vinaceum	+							
Penicillium spp.	+	+	+		+		+	
Phialophora fastigiata			+		+			
Phycomycetes	+	+		+	+	+		

continued...

TABLE XLV (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil
(Delta Marsh, Manitoba) from the 10-20 cm Soil Fraction;
Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Sphaeropsidales	+	+	+	+	+		+	
Trichoderma hamatum			+	+	+		+	
Trichoderma harzianum			+		+	+	+	
Trichosporon sp.							+	
Uiocladium atrum					+			
Verticillium lamellicola							+	
Verticillium lecanii			+					
Verticillium nigrescens			+					
Verticillium tenerum			+	+				
Verticillium tax. sp. I			+					
Volutella ciliata		+			+	+		

TABLE XLVI

Occurrence of Fungi Isolated From Beach Ridge Soil (Delta Marsh, Manitoba) from the 20-30 cm Soil Fraction; Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Acremonium crotocinigenum	+					+		
Acremonium strictum	+		+					
Alternaria alternata			+	+				
Arthroderma curreyi					+			
Ascodesmis sphaerospora	+							
Beauveria bassiana	+				+		+	
Chrysosporium pannorum	+	+	+		+	+	+	
Cladosporium spp.	+							
Cylindrocarpon tax. sp. 1					+			
Cylindrocarpon tax. sp. 4	+	+			+	+		
Cylindrocarpon sp.							+	
Doratomyces nanus							+	
Fusarium graminearum		+						
Fusarium lateritium		+						
Fusarium solani	+							
Fusarium tabacinum	+	+	+	+				
Fusarium tricinctum				+		+		
Fusarium spp.	+	+	+	+	+			
Gliocladium catenulatum				+	+	+	+	
Kernia pachypleura	+	+						
Mortierella alpina	+							
Mortierella hyalina					+	+		
Mycelia Sterilia			+		+		+	
Myrothecium roridum	+						+	

continued...

TABLE XLVI (continued)

Occurrence of Fungi Isolated From Beach Ridge Soil
(Delta Marsh, Manitoba) from the 20-30 cm Soil Fraction;
Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Paecilomyces farinosus	+		+	+	+		+	
Paecilomyces marquandii	+				+			
Penicillium brevi-compactum	+		+		+		+	
Penicillium cf. canescens	+				+		+	
Penicillium cf. citrinum	+	+	+		+			
Penicillium cf. damascenum	+		+	+	+		+	
Penicillium expansum					+			
Penicillium cf. jensenii							+	
Penicillium roseo-purpureum					+	+	+	
Penicillium steckii							+	
Peziza ostracoderma con. st.					+			
Phoma fimeti					+			
Phoma glomerata					+			
Phycomycetes	+		+	+	+	+		
Pyrenochaeta acicola					+			
Pyrenochaeta tax. sp. I						+		
Pyrenochaeta sp.					+			
Rhinocladiella mansonii					+			
Sphaeropsidales	+		+	+	+		+	
Stachybotrys cf. atra	+			+				
Taxonomic genus #1	+							
Trichoderma hamatum	+	+	+	+	+	+	+	
Trichoderma harzianum		+	+		+	+	+	
Verticillium lecanii			+		+			
Volutella ciliata			+		+	+	+	
Volutella sp.	+							

TABLE XLVII

Occurrence of Fungi Isolated from Marsh Soil (Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction; Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Acremonium furcatum					+	+		
Acremonium persicinum				+	+	+	+	
Acremonium strictum			+	+	+	+		
Acremonium sp.					+		+	
Alternaria alternata						+		
Arthrinium phaeospermum							+	
Botryotrichum piluliferum	+	+	+	+	+	+		+
Botrytis cinerea				+				
Chaetomium funicolum								+
Chaetomium spp.		+						
Chrysosporium merdarium var. roseum					+			
Chrysosporium pannorum	+		+	+	+	+	+	+
Chrysosporium spp.					+	+		
Cladosporium sp.				+				
Cylindrocarpon tax. sp. 3	+	+		+	+	+		+
Cylindrocarpon tax. sp. 5			+	+				+
Cylindrocarpon sp.					+			
Dactylaria scaphoides				+				
Doratomyces nanus	+	+	+	+	+	+	+	+
Doratomyces putredinis	+	+	+					
Emericellopsis sp.						+		
Fusarium graminearum	+		+	+	+	+	+	+
Fusarium sporotrichioides			+	+				+
Fusarium tabacinum		+	+	+	+	+	+	+

continued...

TABLE XLVII (continued)

Occurrence of Fungi Isolated from Marsh Soil (Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction; Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Fusarium tricinctum			+	+			+	+
Fusarium spp.					+		+	+
Fusidium cf. griseum						+		
Gliomastic cerealis			+					
Mariannaea elegans var. elegans								
Mortierella alpina			+					
Mortierella sp.				+				+
Myrothecium roridum				+				
Paecilomyces farinosus		+						
Paecilomyces marquandii			+	+	+	+	+	+
Paecilomyces spp.	+	+						
Penicillium brevi-compactum						+	+	+
Penicillium cf. canescens	+	+	+	+				
Penicillium cf. claviforme					+			
Penicillium cf. damascenum	+	+	+	+	+	+	+	+
Penicillium expansum			+					
Penicillium frequentans					+			
Penicillium cf. jensenii			+	+				
Penicillium nigricans	+	+	+	+	+	+	+	+
Penicillium stoloniferum					+	+		
Penicillium spp.	+		+	+	+	+	+	+
Phialophora fastigiata					+			
Phialophora malorum					+			
Phialophora sp. nov.						+		

continued...

TABLE XLVII (continued)

Occurrence of Fungi Isolated from Marsh Soil
(Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction;
Fungi Selected by Four Different Culture Media at all Incubation Temperatures

Name	Culture Medium							
	LCV		SEA		OAES		PDA	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Phycomycetes	+	+		+	+	+		+
Pienodomus sp. nov.					+			
Pyrenochaeta sp.						+		
Rhinocladiella cf. anceps			+					
Rhinocladiella mansonii	+					+		
Sphaeropsidales					+	+		
Sporothrix sp.						+	+	
Sporotrichum epigaeum var. terrestre			+	+	+	+		
Stachybotrys cf. atra								+
Taxonomic genus #1		+		+				+
Trichoderma hamatum			+	+	+	+	+	
Trichoderma harzianum	+	+	+	+	+	+	+	+
Trichoderma viride	+	+	+	+	+	+	+	+
Trichurus spiralis					+			
Verticillium dahliae				+				
Verticillium lamellicola				+				
Verticillium lecanii	+	+		+				
Verticillium nigrescens			+	+	+	+	+	+
Verticillium tenerum						+		
Verticillium spp.						+	+	+

TABLE XLVIII

Occurrence of Fungi Isolated From Marsh Soil (Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction: Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Acremonium furcatum			+	+	+			
Acremonium persicinum	+	+	+	+		+	+	+
Acremonium strictum						+	+	+
Acremonium sp.			+					
Alternaria alternata						+		
Arthrinium phaeospermum			+					
Botryotrichum piluliferum	+	+	+	+		+	+	+
Botrytis cinerea		+						
Chaetomium funicolum				+				
Chaetomium spp.				+				
Chrysosporium merdarium var. roseum			+					
Chrysosporium pannorum	+	+	+	+	+	+	+	+
Chrysosporium spp.	+							
Cladosporium sp.						+		
Cylindrocarpon tax. sp. 3	+	+	+	+	+	+	+	+
Cylindrocarpon tax. sp. 5	+	+	+	+	+			+
Cylindrocarpon sp.			+					
Dactylaria scaphoides								+
Doratomyces nanus	+	+	+	+	+	+	+	+
Doratomyces putredinis	+		+	+				
Emericellopsis sp.						+		
Fusarium graminearum	+	+	+	+	+	+	+	+
Fusarium sporotrichioides	+		+	+				
Fusarium tabacinum	+	+	+	+	+	+	+	+

continued...

TABLE XLVIII (continued)

Occurrence of Fungi Isolated From Marsh Soil
(Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction;
Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Fusarium tricinctum			+		+	+	+	+
Fusidium cf. griseum		+						
Fusarium spp.			+	+	+	+	+	+
Mariannaea elegans var. elegans								
Mortierella alpina							+	
Mortierella sp.		+				+		
Myrothecium roridum						+		
Paecilomyces farinosus		+						
Paecilomyces marquandii	+	+	+	+	+	+	+	+
Paecilomyces spp.						+	+	+
Penicillium brevi-compactum	+	+	+		+	+		+
Penicillium cf. canescens	+	+		+			+	
Penicillium cf. claviforme	+							
Penicillium cf. damascenum	+	+	+	+	+	+	+	+
Penicillium expansum			+					
Penicillium frequentans			+					
Penicillium cf. jensenii						+	+	
Penicillium nigricans	+	+	+	+	+	+	+	+
Penicillium stoloniferum		+	+					
Penicillium spp.	+	+	+		+	+	+	+
Phialophora fastigiata			+					
Phialophora malorum	+							
Phialophora sp. nov.						+		
Phycomycetes	+	+	+	+	+	+	+	+

continued...

TABLE XLVIII (continued)

Occurrence of Fungi Isolated From Marsh Soil
(Delta Marsh, Manitoba) from the 0-10 cm Soil Fraction;
Soil Incubated at Four Different Temperatures on all Culture Media

Name	Incubation Temperature							
	10° C		15° C		20° C		25° C	
	Wash	Soil	Wash	Soil	Wash	Soil	Wash	Soil
Plenodomus sp. nov.			+					
Pyrenochaeta sp.								+
Rhinocladiella cf. anceps					+			
Rhinocladiella mansonii				+			+	
Sphaeropsidales	+	+		+				+
Sporothrix sp.	+		+					
Sporotrichum epigaeum var. terrestre	+			+	+	+		+
Stachybotrys cf. atra								+
Taxonomic genus #1				+		+		
Trichoderma hamatum					+	+	+	+
Trichoderma harzianum	+	+	+	+	+	+	+	+
Trichoderma viride	+	+	+	+	+	+	+	+
Trichurus spiralis	+							
Verticillium dahliae								+
Verticillium lamellicola						+		
Verticillium lecanii					+	+		+
Verticillium nigrescens	+	+	+	+	+	+	+	+
Verticillium tenerum						+		
Verticillium spp.	+	+				+		+

APPENDIX F

CALCULATION OF PROPAGULE NUMBERS

1. Beach Ridge Soil

(a) Wash Water

(i) 0-10 cm Profile

$$\text{Maximum colonies isolated} = \frac{38 \text{ colonies}}{4 \text{ petri plates}}$$

$\frac{38 \text{ colonies}}{4 \text{ ml wash water}}$ at 1:10,000 dilution

$= \frac{9.5 \text{ colonies}}{\text{ml wash water}}$ at 1:10,000 dilution

$= \frac{9500 \text{ colonies}}{\text{ml wash water}}$ at 1:10 dilution

28.12 g dry wt. soil was contained in 270 ml of original wash water (a 1:10 dilution)

$$\frac{9500 \text{ colonies}}{\text{ml wash water}} \times \frac{270 \text{ ml wash water}}{28.12 \text{ g dry wt. soil}} = \frac{91{,}216 \text{ colonies}}{\text{g dry wt. soil}}$$

$$38 \text{ colonies isolated} = 91{,}216 \frac{\text{propagules}}{\text{g dry wt. soil}}$$

$$1 \text{ colony isolated} = 2400 \frac{\text{propagules}}{\text{g dry wt. soil}}$$

(ii) 10-20 cm Profile

$$\text{Maximum colonies isolated} = \frac{56 \text{ colonies}}{4 \text{ petri plates}}$$

$\frac{56 \text{ colonies}}{4 \text{ ml wash water}}$ at 1:10,000 dilution

$= \frac{14 \text{ colonies}}{\text{ml wash water}}$ at 1:10,000 dilution

$= \frac{14000 \text{ colonies}}{\text{ml wash water}}$ at 1:10 dilution

28.12 g dry wt. soil was contained in 270 ml of original wash water (a 1:10 dilution)

(ii) continued

$$\frac{14000 \text{ colonies}}{\text{ml wash water}} \times \frac{270 \text{ ml wash water}}{28.12 \text{ g dry wt. soil}} = \frac{134{,}424 \text{ colonies}}{\text{gm dry wt. soil}}$$

56 colonies isolated = 134,424 $\frac{\text{propagules}}{\text{g dry wt. soil}}$

1 colony isolated = 2400 $\frac{\text{propagules}}{\text{g dry wt. soil}}$

(iii) 20-30 cm Profile

$$\text{maximum number of colonies isolated} = \frac{71 \text{ colonies}}{4 \text{ petri plates}}$$

$\frac{71 \text{ colonies}}{4 \text{ ml wash water}}$ at 1:10,000 dilution

= $\frac{17.8 \text{ colonies}}{\text{ml wash water}}$ at 1:10,000 dilution

= $\frac{17{,}800 \text{ colonies}}{\text{ml wash water}}$ at 1:10 dilution

28.12 g dry wt of soil was contained in 270 ml of original wash water (a dilution of 1:10)

$$\frac{17{,}800 \text{ colonies}}{\text{ml wash water}} \times \frac{270 \text{ ml wash water}}{28.12 \text{ g dry wt soil}} = \frac{170{,}910 \text{ colonies}}{\text{g dry wt.soil}}$$

71 colonies isolated = $\frac{170{,}910 \text{ propagules}}{\text{g dry wt. soil}}$

1 colony isolated = $\frac{2407 \text{ propagules}}{\text{g dry wt. soil}}$

(b) Washed Soil

* maximum number colonies = $\frac{103 \text{ colonies}}{4 \text{ petri plates}}$

average mass soil transferred = 0.0353 $\frac{\text{g dry wt.}}{\text{petri plate}}$

$\frac{103 \text{ colonies}}{4 \text{ petri plates}} = \frac{26 \text{ colonies}}{\text{petri plate}}$

* based on maximum colonies counted for 0-30 cm profile

(b) continued

$$\frac{26 \text{ colonies}}{.0353 \text{ g dry wt. soil}} = \frac{737 \text{ colonies}}{\text{g dry wt. soil}}$$

$$26 \text{ colonies} = \frac{737 \text{ propagules}}{\text{g dry wt. soil}}$$

$$1 \text{ colony} = \frac{28 \text{ propagules}}{\text{g dry wt. soil}}$$

2. Marsh Soil

(a) Wash Water - 0-10 cm Profile

$$\text{maximum number colonies isolated} = \frac{80 \text{ colonies}}{3 \text{ petri plates}}$$

$$\frac{80 \text{ colonies}}{3 \text{ ml wash water}} \text{ at } 1:1{,}000 \text{ dilution}$$

$$= \frac{26.7 \text{ colonies}}{\text{ml wash water}} \text{ at } 1:1{,}000 \text{ dilution}$$

$$= \frac{2{,}670 \text{ colonies}}{\text{ml wash water}} \text{ at } 1:10 \text{ dilution}$$

30g dry wt. soil was contained in 270 ml of original wash water (a 1:10 dilution)

$$\frac{2{,}670 \text{ colonies}}{\text{ml wash water}} \times \frac{270 \text{ ml wash water}}{30 \text{ g dry wt. soil}} = 24{,}030 \frac{\text{colonies}}{\text{g dry wt. soil}}$$

$$80 \text{ colonies isolated} = 24{,}030 \frac{\text{colonies}}{\text{g dry wt. soil}}$$

$$1 \text{ colony isolated} = \frac{300 \text{ propagules}}{\text{g dry soil}}$$

(b) Washed Soil - 0-10 cm Profile

Maximum number colonies isolated = $\frac{84 \text{ colonies}}{3 \text{ ml}}$

average mass soil transferred = $\frac{0.319 \text{ g dry wt.}}{\text{ml}}$

0.319 g dry wt. soil diluted 1:1,000 =

$$.000319 \frac{\text{g dry wt. soil}}{\text{ml}}$$

$$\frac{.000319 \text{ g dry wt. soil}}{\text{ml}} \times 3 \text{ ml} = .000957 \text{ g}$$

$$\frac{84 \text{ colonies}}{.000957 \text{ g dry wt. soil}} = \frac{87{,}500 \text{ colonies}}{\text{g dry wt. soil}}$$

84 colonies isolated = $\frac{87{,}500 \text{ propagules}}{\text{gm dry wt. soil}}$

1 colony isolated = 1042 $\frac{\text{propagules}}{\text{g dry wt. soil}}$

LITERATURE CITED

Ainsworth, G.C. 1961. Ainsworth's and Bisby's The Dictionary of the Fungi 5th Ed. Commonwealth Mycological Institute, Kew, Surrey.

Ames, L.M. 1961. A monograph of Chaetomiaceae no. 2. The United States Army Research and Development Series. U.S. Government Printing Office.

Barnett, H.L. and B.B. Hunter. 1972. Illustrated genera of imperfect fungi. Burgess Publishing Co., Minneapolis, Minnesota.

Barron, G.L. 1968. The genera of Hyphomycetes from soil. The Williams and Wilkins Company, Baltimore, Md., U.S.A.

Beljakova, L.A. 1974. Genus Emericellopsis Van Beyma (Eurotiaceae) Mikologiya Fitopatologiya 8(5): 385-395.

Bhatt, G.C. 1970. The soil microfungi of white cedar forests in Ontario. Can. J. Bot. 48: 333-339.

Bisby, G.R., N. James, and M. Timonin. 1933. Fungi isolated from Manitoba soil by the plate method. Can. J. Res. 8: 253-275.

Bisby, G.R., M.I. Timonin, and N. James. 1935. Fungi isolated from soil profiles in Manitoba. Can. J. Res. (C) 13: 47-65.

Bisby, G.R., A.H.R. Buller, J. Dearness, W.P. Fraser, and R.C. Russell. 1938. Fungi of Manitoba and Saskatchewan. Pub. Nat. Res. Council of Canada, Ottawa, Canada.

Bissett, J.D. 1975. The ecology of fungi occurring in soils along an alpine ridge. Ph.D. Thesis. University of Calgary, Calgary, Alta.

Bissett, J. 1979. Paecilomyces farinosus in Fungi Canadenes No. 153. S.J. Hughes Editor. National Mycological Herbarium Biosysternatics Research Institute, Research Branch, Agriculture Canada.

Bissett, J. and D. Parkinson. 1979 a. The distribution of fungi in some alpine soils. Can. J. Bot. 57: 1609-1629.

Bissett, J. and D. Parkinson. 1979 b. Fungal community structure in some alpine soils. Can. J. Bot. 57: 1630-1641.

Bissett, J. and D. Parkinson, 1979 c. Functional relationships between soil fungi and environment in alpine tundra. Can. J. Bot. 57: 1642-1659.

Bissett, J. and D. Parkinson. 1980. Long term effects of fire on the composition and activity of soil microflora of a subalpine coniferous forest. Can. J. Bot. 58: 1704-1721.

Boerema, G.H. and H.A. van Kesteren. 1963. The nomenclature of two fungi parasitizing Brassica. Persoonia 3: 17-28.

Booth, C. 1966. Mycological Paper No. 104. The genus Cylindrocarpon. Commonwealth Mycological Institute, Kew. Surrey.

Booth, C. 1971. The genus Fusarium. Commonwealth Mycological Insititute, Kew, Surrey.

Brierley, W.B., S.T. Jewson, and M. Brierley. 1927. The quantitative study of soil fungi. Proc. First Int. Congr. Soil Science. Vol. 3: 48-71.

Brown, J.C. 1958. Soil fungi of some British sand dunes in relation to soil type and succession. J. Ecol. 46: 641-664.

Brown, A.H.S. and G. Smith. 1957. The genus Paecilomyces bainier and its perfect stage Cyssochlamys westling. T.B.M.S. 40: 17-89.

Burges, N.A. and D.P. Nicholas. 1961. Use of soil sections in studying the amount of fungal hyphae in soil. Soil. Sci. 92: 25-29.

Carmichael, J.W. 1962. Chrysosporium and some other aleuriosporic hyphomycetes. Can. J. Bot. 40: 1137-1173.

Chesters, C.G.C. 1940. A method of isolating soil fungi. Trans. Brit. Mycol. Soc. 24: 352-355.

Chesters, C.G.C. 1948. A contribution to the study of soil fungi. Trans. Brit. Mycol. Soc. 30: 100-117.

Chesters, C.G.C. 1949. Concerning fungi inhabiting soil. Trans. Brit. Mycol. Soc. 32 (3 and 4): 197-216.

Chesters, C.G.C. 1960. Certain problems associated with the decomposition of soil organic matter by fungi in The Ecology of Soil Fungi. Liverpool University Press. pp. 223-238.

Chesters, C.G.C. and R.H. Thornton. 1956. A comparison of techniques for isolating soil fungi. Trans. Brit. Mycol. Soc. 39 (3): 301-313.

Cholodny, N. 1930. Über eine neue Methode zur Untersuchung der Bodenmikoflora. Arch. Mikrobiol. I: 620-652.

Chou, C.K. and R.C. Stephen. 1968. Soil fungi their occurrence distribution and association with different microhabitats together with a comparative study of isolation techniques. Nova Hedwigia 15: 393-409.

Clements, F.E. and C.L. Shear. 1931. Genera of fungi. H.W. Wilson Co., New York.

Cohen, C. 1950. An examination of the methods used for isolating soil fungi. S. Afr. J. Sci. 46: 281-283.

Crook, P.C., C.C. Carpenter, and P.F. Klens. 1950. The use of sodium propionate in isolating actinomycetes from soils. Science 112: 656.

Danielson, R.M. and C.B. Davey. 1973. The abundance of Trichoderma propagules and the distribution of species in forest soils. Soil Biol. and Biochem. 5: 485-494.

de Hoog, G.S. 1972. Studies in mycology no. 1. The genera Beauveria, Isaria, Tritirachium and Acrodontium gen. nov. Centraalbureau Voor Schimmelcultures, Baarn.

Dickinson, C.H. and J.W. Kent. 1972. Critical analysis of fungi in two sand dune soils. Trans. Brit. Mycol. Soc. 58 (2): 269-280.

Dickinson, C.H. and G.J.F. Pugh. 1965. Use of a selective cellulose agar for isolation of soil fungi. Nature, London 207: 440-441.

Domsch, K.H. and W. Gams. 1970. Pilze aus Agrarboden. Gustlav Fischer Verlag, Stuttgart.

Dorenbosch, Maria M.J. 1970. Key to Nine Ubiquitous Soil-Borne Phoma-like Fungi. Persoonia 6 (1): 1-14

Egdell, J.W., W.A. Cuthbert, C.A. Scarlett, S.B. Thomas, and M.H. Westmacott. 1960. Some studies on the colony count technique for soil bacteria. J. appl. Bact. 23: 69.

Ehrlich, W.A., E.A. Poyser, and L.E. Pratt. 1957. Report of Reconnaissance Soil Survey of Carberry Map Sheet Area. Man. Soil Survey Report No. 7.

Ellis, M.B. 1965. Mycological Paper 103. Dematiaceous Hyphomycetes VI. Commonwealth Mycological Institute, Kew, Surrey. pp. 8-10.

Ellis, M.B. 1971. Dematiaceous Hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey.

Gams, W. 1971. Cephalosporium artige Schimmelpilze. Gustav Fisher Verlag, Stuttgart.

Gams, W. and K.H. Domsch. 1969. The spatial and seasonal distribution of microscopic fungi in arable soils. Trans. Brit. Mycol. Soc. 52 (2): 301-308.

Gams, W. and M. Gerlagh. 1968. Beiträge Zur Systematik Und Biologie von Plectosphaerella cucumeris Und Der Zugehörigen Konidionform. Persoonia 5 (2): 177-188.

Garrett, S.D. 1951. Ecological groups of soil fungi: a survey of substrate relationships. New Phytol. 50: 149-166.

Garrett, S.D. 1955. Microbial ecology of the soil. Trans. Brit. Mycol. Soc. 38: 1-9.

Gilman, J.E. 1959. A manual of soil fungi. Iowa State University Press, Ames, Iowa.

Glynne, M.D. 1939. Fungal invasion of roots of healthy wheat plants. Trans. Brit. Mycol. Soc. 23: 210.

Gochenaur, S.E. and W.F. Whittingham. 1967. Mycoecology of Willow and cottonwood lowland communities in southern Wisconsin I. Soil microfungi in the willow-cottonwood forests. Mycopathol. Mycol. Appl. 33: 125-139.

Gordon, W.L. 1944. The occurence of Fusarium species in Canada I. Species of Fusarium isolated from farm samples of cereal seed in Canada. Can. J. Res. C 22: 282-286.

Gordon, W.L. 1954. The occurence of Fusarium species in Canada IV. Taxonomy and prevelence of Fusarium species in the soil of cereal plots. Can. J. Bot. 32: 622-629.

Gordon, W.L. 1959. The occurence of Fusarium species in Canada VI. Taxonomy and geographic distribution of Fusarium species on plants, insects and fungi. Can. J. Bot. 37: 257-290.

Harley, J.L. and J.S. Waid. 1955. A method of studying active mycelia on living roots and other surfaces in the soil. Trans. Brit. Mycol. Soc. 38: 104-118.

Hawker, L.F. 1950. Physiology of Fungi. London University Press.

Hawker, L.E. and A.H. Linton. Ed. 1971. Micro-Organisms: Function Form and Environment. Pub. Edward Arnold Ltd.

Hughes, S.J. 1958. Revisiones Hyphomycetum Aliquot Cum Appendice De Nominibus Rejiciendis - Can. J. Bot 26: 727-836.

Isakova, A.A. 1938. Experimental application of Rossi-Cholodny's method to study bacteriosis in various plants. Bull. Acad. Sci. U.R.A.A. 2: 517-522.

Ivarsen, K.C. 1965. The microbiology of some permafrost soils in the Mackenzie Valley. N.W.T. Arctic 18: 256-260.

Ives, W.G.H., N.R. Brandt, and B.C. Sutton. 1968. Manitoba-Saskatchewan Region. Ann. Rep. For. Insect and Disease Surv. 1967: 76-96.

James, N. and M.L. Sutherland. 1939. The accuracy of the plating method for estimating the numbers of bacteria and fungi from one dilution and from one aliquot of a laboratory sample of soil. Can. Journ. Res. 17 (C): 97-108.

Jensen, C.N. 1912. Fungous flora of the soil. Cornell Univ. Agric. Exper. Station Bull. 315: 414-501.

Jensen, H.L. 1931. The fungus flora of the soil. Soil Sci. 31: 123-158.

Jones, P.C.T. and J.E. Mollison. 1948. A technique for the quantitative estimation of micro-organisms. J. Gen. Microbiol., 2: 54-69.

Kendrick, W.B. 1962. Soil fungi of a copper swamp. Can. J. Microbiol. 8: 639-647.

Kurbis, W.P. 1937. Mykologische Untersuchungen über den Wurzelbereich der Ersche. Flora (Jena) 131: 129-175.

Lisina-Kulik, E.S. and N.G. Moiseeva. 1971. Effect of soil sample size and shaking and sedimentation time of soil suspension on the count of fungi microphytes. Vestnik Moskovskogo Universiteta, Serieja 6: Biologiya, Pochoo 26 (5): 86-92.

Littman, M.L. 1947. A culture medium for the primary isolation of fungi. Science 106: 109-111.

Löve, A. and D. Löve. 1954. Vegetation of a Prairie Marsh. Bull. Torrey Bot. Club 81 (1): 16-34.

MacLeod, D.M. 1954. Investigation of the genera Beauveria Vuill. and Tritirachium Limber. Can. J. Bot. 32: 818-890.

Malloch, D. and R.F. Cain. 1971. The genus Kernia. Can. J. Bot. 49 (6): 855-867.

Martin, J.P. 1950. Use of acid rose bengal, and streptomycin in the plate method for estimating soil fungi. Soil Sci. 69: 215-232.

Menzies, 1957. A dipper technique for serial dilutions of soil for microbial analysis. Soil Sci. Soc. Am. Proc. 21: 660.

Miller, O.K. and G.A. Laursen. 1974. Belowground fungal biomass on U.S. Tundra Biome sites at Barrow, Alaska. In Soil Organisms and Decomposition in Tundra Edited by A.J. Holding, O.W. Heal, S.F. MacLean and P.W. Flanagan. IBP Tundra Steering Committee, Stockholm. pp. 151-158.

Montégut, J. 1960. Value of the dilution method In The Ecology of Soil Fungi International Symposium. Liverpool University Press.

Morrall, R.A.A. and T.C. Vanterpool. 1968. The soil microfungi of upland boreal-forest at Candle Lake, Saskatchewan. Mycologia, 60: 642-654.

Morton, F.J. and G. Smith. 1963. Micological Paper No. 86. The genera Scopulariopsis Bainer, Microascus Zukal, and Doratomyces Corda. Commonwealth Mycological Institute, Kew, Surrey.

Newman, A.S. and A.G. Norman. 1943. The activity of subsurface pupulations. Soil Sci. 55: 377-391.

Nicot, J. and J. Chevaugeon. 1949. Comparison des methodes d'isolement de la microflora fongique du sol. Etude d'un terreau de serres du museum. Bull. Mus. His. Nat., Paris 31: 384-392.

Obrist, O. 1961. The genus Ascodesmis. Can. J. Bot. 39: 948-950.

Panasenko, V.T. 1967. Ecology of Microfungi. Botanical Rev. 33 (3): 189-215.

Parkinson, D. 1970. Methods for quantitative study of heterotrophis coil micro-organisms. In Methods of Study in Soil Ecology Proceedings of the Paris Symposium organized by Unesco and The International Biological Programme.

Parkinson, D. and W.B. Kendrick. 1960. Investigations of soil microhabitats. In Ecology of Soil Fungi Liverpool Press. pp. 22-28.

Parkinson, D. and A. Thomas. 1965. A comparison of methods for the isolation of fungi from rhizospheres. Can. J. Microbiol. 11: 1001-1007.

Parkinson, D. and S.T. Williams. 1961. A method for isolating fungi from soil microhabitats. Plant and Soil 13 (4): 347-355.

Parkinson, D., T.R.G. Gray, J. Holding, and H.M. Nagel-De-Boois. 1971. In Methods of Study in Quantitative Soil Ecology: population, production and energy flow. Blackwell Scientific Publications, Oxford and Edinburgh.

Peach, M. 1952. Aquatic predacious fungi II. Trans. Brit. Mycol. Soc. 35: 19-23.

Phillips, S.F. 1976. The Relationship Between Evapotranspiration by Phragmites communis Tvin. and Water Table Fluctuations in Delta Marsh, Manitoba. Ph. D. Thesis.

Pugh, G.J.F. 1962. Studies on fungi in coastal soils II. Fungal ecology in a developing salt marsh. Trans. Brit. Mycol. Soc. 45 (4): 560-566.

Pugh, G.J.F. 1963. Ecology of fungi in developing coastal soils. Soil Organisms. North Holland Publishing Co., Amsterdam, Holland.

Pugh, G.J.F., J.P. Blakeman, G. Morgan-Jones, and H.O.W. Eggins. 1963. Studies on fungi in coastal soils IV. Cellulose decomposing species in sand dunes. Trans. Brit. Mycol. Soc. 46 (4): 565-571.

Raper, K.B. and C. Thom. 1968. A manual of the Penicillia. Hafner Publishing Co., New York and London.

Reddy, T.K.R. and R. Knowles. 1965. The fungal flora of a boreal forest raw humus. Can. J. Microbiol. 11: 837-843.

Rifai, M.A. 1969. Mycological Paper No. 116. A revision of the genus Trichoderma. Commonwealth Mycological Institute, Kew, Surrey.

Robertson, N.F. 1954. Studies on mycorrhizes of Pinus sylvestris. New Phytol. 53: 253-283.

Rose, R.E. and J.G. Miller. 1954. Some sampling variations in soil fungal numbers. J. Gen. Microbiol. 10: 1-10.

Rossi, G.M. 1928. Il terreno agrario nella teoria e nella realta. Ital. agric. no. 4.

Saito, T. 1955. Soil microflora of a coastal dune. Sci. Rep. Tôhoku Univ. 21: 145-151.

Samson, R.A. 1974. Studies in Mycology No. 6. Paecilomyces and some allied Hyphomycetes. Centralbureau Voor Schimmelcultures, Baarn.

Schol-Schwarz, B.M. 1970. Revision of the genus Phialophora. Persoonia 6 (1): 59-94.

Sewell, G.W.F. 1959 a. The ecology of 6 fungi in Calluna-heathland soils. New Phytologist 58: 5-17.

Sewell, G.W.F. 1959 b. Studies of fungi in a Calluna-heathland soil I. Vertical distribution in soil and on root surfaces. Trans. Brit. Mycol. Soc. 42 (3): 343-353.

Sewell, G.W.F. 1959 c. Studies of fungi in a Calluna-heathland soil II. by the complementary use of several isolation methods. Trans. Brit. Mycol. Soc. 42 (3): 354-369.

Simmonds, P.M. 1930. A washing device for isolation work with plant material. Phytopathology 20: 911-913.

Skinner, F.E., P.C.T. Jones, and J.E. Mollison. 1952. A comparison of a direct and plate counting technique for the quantitative estimation of soil microorganisms. J. Gen. Microbiol. 6: 261.

Smith, N.R. and V.T. Dawson. 1944. The bacteriostatic action of rose bengal in media used for the plate counts of soil fungi. Soil Sci. 58: 467-471.

Steiner, W.G. and D. Watson. 1965. Use of surfactants in the soil dilution and plate count method. Phytopath. 55: 728-730.

Stenton, H. 1953. The soil fungi of Wicken fen. Trans. Brit. Mycol. Soc. 36: 304-314.

Stolk, A.C. 1955. Emericellopsis minima and Westerdijkella ornata. Trans. Brit. Mycol. Soc. 38: 419-424.

Sutton, B.C. 1968. List of species deposited in the Mycological Herbarium of the Forest Research Laboratory, Winnipeg, Manitoba. Supplement I. Internal Report MS-68. Forestry Branch, Dept. of Fisheries and Forestry, Province of Manitoba.

Sutton, B.C. 1973. Mycological Paper No. 132. Hyphomycetes from Manitoba and Saskatchewan, Canada. Commonwealth Mycological Institute, Kew, Surrey, England.

Sutton, B.C. 1977. Mycological Paper No. 141. Coelomycetes VI. Nomenclature of generic names proposed for coelomycetes. Commonwealth Mycological Institute, Kew, Surrey.

Taber, W.A. 1951. Fungi of two forest soils of Johnson county. Iowa Acad. Sci. 58: 209-214.

Tews, L.T. 1970. Microfungi in the water, mud, and litter of a cattail marsh. Proc. 13th Conf. Great Lakes Res., Internat. Assoc. Great Lakes Res., 106-113.

Tews, L.T. 1971. The effects of selected fungicides and soil fumigants upon the microfungi of a cattail marsh. Proc. 14th Conf. Great Lakes Res., Internat. Assoc. Great Lakes Res.

Thomas, A. and D. Parkinson. 1967. The initiation of the rhizosphere mycoflora of dwarf bean plants. Can. J. Microbiol. 13: 439-446.

Tulloch, M. 1972. Mycological Paper No. 130. The genus Myrothecium Tode ex Fr. Commonwealth Mycological Institute, Kew, Surrey.

Turner, M. and G.J.F. Pugh. 1961. Species of Mortierella from a salt marsh. Trans. Brit. Mycol. Soc. 44 (2): 243-252.

Tyner, L.E. 1944. The effect of media composition on the number of bacterial and fungal colonies developing on petri plates. Soil Sci. 57: 271-274.

Vaartaja, O. 1968. Pythium and Mortierella in soils of Ontario forest nurseries. Can. J. Microbiol. 14: 265-269.

von Arx, J.A. 1970. The genera of fungi sporulating in pure culture. Verlog von J. Cramer, Germany.

Waksman, S.A. 1916. Soil fungi and their activities. Soil Sci. 2: 103-155.

Waksman, S.A. 1922. The growth of fungi in the soil. Soil Sci. 14: 153-157.

Waksman, S.A. 1927. Principles of Soil Microbiology. The Williams and Wilkins Company, Baltimore.

Walker, J.M. 1959. Vegetation Studies on the Delta Marsh, Delta, Manitoba. M.Sc. Thesis.

Wallace, B. and C.H. Dickinson. 1978. Peat microfungi in three habitats in the Florida Everglades. Trans. Brit. Mycol. Soc. 70 (6): 1151-1163.

Warcup, J.H. 1950. The soil-plate method for isolation of fungi from soil. Nature 166: 117-118.

Warcup, J.H. 1955 a. On the origin of colonies of fungi developing on soil dilution plates. Trans. Brit. Mycol. Soc. 38 (3): 298-301.

Warcup, J.H. 1955 b. Isolation of fungi from hyphae present in soil. Nature 175: 953-954.

Warcup, J.H. 1957. Studies on the occurrence and activity of fungi in wheat-field soil. Trans. Brit. Mycol. Soc. 40 (2): 237-262.

Watson, R.D. 1960. Soil washing improves the value of the soil dilution and the plate count method of estimating populations of soil fungi. Phytopath. 50: 792-794.

Wicklow, M.C., W.B. Bollen, and W.C. Denison. 1974. Comparison of soil microfungi in 40-year old stands of pure alder, pure conifer, and alder-conifer mixtures. Soil Biol. Biochem. 6 (2): 73-78.

Widden, P. 1979. Fungal populations from forest soils in Southern Quebec. Can. J. Bot. 57 (12): 1324-1331.

Widden, P. and D. Parkinson. 1973. Fungi from Canadian coniferous forest soils. Can. J. Bot. 51: 2275-2290.

Widden, P. and D. Parkinson. 1979. Populations of fungi in a high arctic ecosystem. Can. J. Bot. 57: 2408-2417.

Williams, L.E. and A.F. Schmitthenner. 1956. Genera of fungi in Ohio soils. Ohio Agric. Ex. Res. Sta. C. 39: 1-7.

Williams, S.T. and D. Parkinson. 1964. Studies of fungi in a podzol I. Nature and fluctuation of the fungus flora of the mineral horizons. Journ. of Soil Science 15 (2): 332-341.

Williams, S.T., D. Parkinson, and N.A. Burges. 1965. An examination of the soil washing technique by its application to several soils. Plant and Soil, 22 (2): 167-186.

Wohlrab, F. and R.W. Tuveson. 1965. Distribution of fungi in early stages of succession in Indiana dune sand. Amer. Jour. Bot. 52 (10): 1050-1058.

Wohlrab, G., R.W. Tuveson, and C.E. Olmsted, 1963. Fungal populations from early stages of succession in Indiana dune sand. Ecology 44 (4): 734-740.

Ziemiecka, J. 1935. The use of a modified Rossi-Cholodny technique for studying the organisms that decompose certain organic compounds in the soil. Zkl. Bakt. (Abt 2) 91: 379-394.