A SURVEY OF
AQUATIC LIGNICOLOUS FUNGI
IN THE AREA ABOUT BLACKSBURG, VIRGINIA

by

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INTRODUCTION

A survey of the literature reveals little information concerning the aquatic fungi associated with submerged wood debris. During the past fifteen years several mycologists have studied such lignicolous fungi, but their efforts have been confined almost entirely to marine and brackish waters (Johnson and Sparrow, 1961; Meyers and Reynolds, 1960; Kohlmeyer, 1960). It was thought that a study of similar organisms in freshwater environments would make a significant addition to our knowledge of aquatic mycology. This study would commence with the traditional approach to such problems, that is the collection, identification, and description of the organisms. This would provide a basis for further research on their ecology and physiology.

The taxonomy of these fungi was found to be quite difficult and often controversial. There are no adequate manuals, and, in many cases, identification of a fungus required a search of the literature. Many of the descriptions in the literature were insufficient and some almost useless. This descriptive work was time-consuming and left little opportunity for work on the physiology and ecology of the fungi. This study, then, has been primarily taxonomic. It should contribute to the field of aquatic mycology by providing a firm basis for further research on the fresh-water lignicolous fungi.

Aquatic lignicolous fungi in the area about Blacksburg, Virginia were collected and examined. Descriptions of these fungi, with illustrations, and a key to their identification are given in this paper. The collecting procedure and a brief discussion on the ecology of these fungi are also included.

I wish to thank Dr. William W. Scott for the initiation and general supervision of this study. Appreciation is also extended to Dr. F.S. Orcutt, Head, Department of Biology, and members of my graduate committee for suggestions on specific problems arising during the investigation. I am indebted to Dr. T.W. Johnson, Jr., Department of Botany, Duke University, for examining many of the collections and helping with their identification.

MATERIALS AND METHODS

To collect aquatic lignicolous fungi, wood panels were submerged awhile, incubated in moisture chambers, and examined with a dissecting microscope for fungal reproductive structures. These were then transferred to slides for examination under high power.

The panels, of yellow pine and poplar, 5.1 x 10.2 x 2.5 cm. were obtained from a local lumber yard. They were drilled, one hole each, wrapped in newspaper, and autoclaved for one hour. Then they were taken to collecting stations, assembled into traps, and submerged. Each trap consisted of two pine and two poplar panels, strung together through the drill holes and anchored to a brick with Kordite clothes line. The wood panels were allowed to float off the bottom to prevent silting in, but at a depth beneath the low water mark. Later, the traps were pulled from the water; the panels unstrung, placed in polyethylene bags and brought to the laboratory. They were taken from the bags, placed in sterile moisture chambers, and incubated at room temperature. Each moisture chamber held the four panels of a trap and consisted of two Pyrex baking dishes sealed with masking tape.

Stations that represent the various types of aquatic sites in the area of Blacksburg, Virginia were chosen and are listed in table 1. A minimum submergence period of fifteen days was allowed, as recommended by Siepmann and Johnson (1960), but the period was always much longer. Submergence periods are given in table 1.

Incubation of the wood is the procedure of Meyers and Reynolds (1958) and Johnson, Ferchau, and Gold (1959) to facilitate identification and isolation of the infesting fungi. Wood showing little or no fungal growth, when taken from the water, often develops considerable populations during incubation. At the suggestion of Dr. T.W. Johnson, Jr., wood was incubated as long as possible to allow development of slowly growing forms. Incubation periods are given in table 1.

After incubation the wood was taken from the moisture chambers and examined with a dissecting microscope. Reproductive structures - conidia and conidiophores, pycnidia, perithecia - were plucked from the wood surface with a needle and mounted. Permanent mounts were made in Amman's medium and assigned a collection number. A few of the fungi were isolated and studied in culture.

All of our collections are described in this paper, including those that could not be identified. Generic descriptions have been adapted. Descriptions of species have been taken from the literature when they have seemed adequate to describe our own collections. Adapted descriptions have been changed in format only. Modified descriptions have been changed in content, the modification being explained in each case. In all descriptions of species, descriptions of colonies on wood are my own. The key includes only the identified collections.

Table 1. Collecting stations and trap records.

Collecting station	Trap	Collection date	Submergence period (months)	Incubation period (months)
Duck Pond, V.P.I. campus, Blacksburg, Va. - eastern shore.	A	9/21/61	3	13
	B	12/16/61	3	10
Sinking Creek, Giles County, Va. - Ca. 4 mi. below Newport.	A	9/19/61	3	4
	B	12/16/61	3	7
	C	6/28/62	6	20
	D	6/ 6/63	12	8
	E	6/ 6/63	12	1½
Mountain Lake, Giles County, Va. - western shore.	A	7/18/62	7	22
	B	6/17/63	11	1
Claytor Lake, Pulaski County, Va. - southeastern shore.	A	12/16/61	3	6
	B	10/22/62	10	18
Big Stoney Creek, Giles County, Va. - Ca. 1 mi. above Interior.	A	12/ 1/61	3	26
	B	6/ 6/63	12	1½
Tom's Creek, Montgomery County, Va. - at Longshop.	A	7/17/62	1	12
	B	6/11/63	11	1½
Poverty Creek, Montgomery County, Va. - along Poverty Creek Rd., Ca. 4 mi. off U.S. Rt. 460.		6/ 6/63	12	1½

KEY TO THE FUNGI

A. Spores produced in asci within perithecia. . . .Pyrenomycetes, p. 49

A. Spores not produced in asci. . . . . B

B. Hyphae very slender, ca. 1 u thick, producing arthrospores but no conidia. . . . . Nocardia, p. 48

B. Hyphae much thicker, conidia usually, arthrospores seldom, produced. . . . . .Fungi Imperfecti

Genera of Aquatic Lignicolous Fungi Imperfecti

A. Conidia produced in pycnidia . . . . . B

A. Conidia not produced in pycnidia . . . . . D

B. Conidia multicellular . . . . . Stagonospora, p. 46

B. Conidia unicellular C

C. Conidia brown. . . . . Coniothyrium, p. 45

C. Conidia hyaline to subhyaline. . . . . .Aposphaeria, p. 43

D. Conidia and conidiophores in sporodochia. . . . . E

D. Conidia and conidiophores separate. . . . . H

E. Conidia filamentous, coiled, multiseptate, hyaline . Hobsonia, p. 39

E. Conidia not as above . . . . . F

F. Conidia hyaline, unicellular and/or multicellular . . . . . Fusarium, p. 36

F. Conidia brown, multicellular. . . . . G

G. Conidia muriform . . . . . .Dictyosporium, p. 15

G. Conidia with transverse septa only . . . . . .Bactrodesmium, p. 41

H. Conidia and conidiophores hyaline I

H. Conidia and/or conidiophores with dark pigment. . . . . M

I. Conidia filamentous, coiled or curved. . . . . J

I. Conidia not as above . . . . . K

J. Each conidium a coiled hyphae . . . . . .Helicomyces, p. 38

J. Each conidium a spherical network of branching and meeting hyphal tips . . . . . Clathrosphaerina, p. 35

K. Conidia uniseptate only. . . . . Arthrobotrys, p. 34

K. Conidia aseptate and/or aseptate to multiseptate L

L. Conidiophores slender, branching whorled; conidia unicellular, ovoid to ellipsoidal . . . . . Verticillium, p. 40

L. Conidiophores usually stout, branches seldom in whorls; conidia elongated, multicellular, large and/or ovoid, unicellular, small . . . . . Fusarium, p. 36

M. Conidia aseptate . . . . . N

M. Conidia septate. . . . . R

N. Conidia opaque. . . . . .Monotospora, p. 22

N. Conidia hyaline or subhyaline . . . . . O

O. Conidiophores very short, separating from hyphae and remaining attached to conidia. . . . . Humicola, p. 20

O. Conidiophores tall, erect, not as above. . . . . P

P. Conidiophores unbranched, conidia produced endogenously . . . . . Bisporomyces, p. 13

P. Conidiophores branched, conidia produced exogenously. . . . . Q

Q. Conidiophores branched penicillately, sterile branches never present. . . . . .Leptographium, p. 21

Q. Conidiophore branches in whorls arising from hyphal collars along the main stalk; long, slender, sterile branches often present. . . . . .Gonytrichum, p. 18

R. Conidia with transverse septa only. . . . . S

R. Conidia with both transverse and longitudinal septa . . . . . W

S. Conidia catenulate . . . . . .Septonema, p. 25

S. Conidia not catenulate . . . . . T

T. Conidia almost sessile, usually opaque at apex. . . . . .Trichocladium, p. 32

T. Conidiophores usually tall, conidia never opaque. . . . . U

U. Conidia produced endogenously. . . . . Sporoschisma, p. 31

U. Conidia produced exogenously V

V. Conidia borne in terminal heads . . . . . .Cacumisporium, p. 14

V. Conidia borne singly at apices of conidiophores . . . . . Sporidesmium, p. 28

W. Conidia consisting of parallel branches. . . . .Dictyosporium, p. 15

W. Conidia not of parallel branches X

X. Conidia catenulate, never opaque. . . . . Alternaria, p. 12

X. Conidia not catenulate, often opaque. . . . . .Piricauda, p. 23

DESCRIPTIONS OF FUNGI COLLECTED

Order: Moniliales

Family: Dematiaceae

Alternaria Nees
Syst. Pilz., 2: 72. 1817.

The conidiophores are solitary or fasciculate, erect or subdecumbent, simple or branched, mostly colored, and septate.

The conidia are borne singly or in chains of up to twenty or more. They are muriform with transverse, longitudinal, and sometimes oblique septa, the number and kind of septa varying greatly. The conidia are typically obclavate with rounded base and are often provided with a beak, which may be poorly developed, branched or unbranched, short or up to five times the length of the spore-body. The conidial surface may be rounded or smooth. The conidia often exhibit secondary growth by the continued division and enlargement of the cells resulting in irregularly shaped conidia and sometimes in the breaking up of the spore-body. The conidia germinate by germ-tubes given out from any cell. (Condensed from Wiltshire, 1933)

Alternaria sp.
(Fig. 7)

The colonies on agar are greenish-brown. The conidia are brown and muriform or phragmosporous, usually with 3-5 cross-septa. The shape is elliptical, obclavate, or ovoid. The conidia are 24-35 μ long x 9-14 μ broad.

Collected: Sinking Cr., monocot debris, trap D; Sinking Cr., pine, trap A.

Identification of species of Alternaria is very difficult due to the great polymorphism of the conidia in culture, and clues to differences of specific rank have not been elucidated (Mason, 1928). Our collection would seem to fall into the A. tenuis group as defined by Mason (1928); that is, the conidia are obclavate, are 20-50 x 10-14 μ, usually have 3-5 cross-septa, and are borne in long chains.

Bisporomyces van Beyma
A. Van Leeuwenhoek; Nederlandsch Tijdscrift
V. Hyg., Microb., & Serol., 6: 276. 1940.

The turf is from smokey-gray to blackish. Hyphae are brown, septate. Phialid are long and narrow, brown, septate, at the top two conidia are produced together, as in species of the genus Phialophora. The conidia are numerous, being colorless to lightly colored. (Translated from van Beyma, 1940)

Bisporomyces chlamydosporis van Beyma
A. Van Leeuwenhoek; Nederlandsch Tijdscrift
V. Hyg., Microb., & Serol., 6: 277. 1940.
(Fig. 5)

The fungus appears on wood as sparse erect conidiophores with heads of conidia.

The conidiophores are simple, tall and slender, erect, septate, dark brown, 105-375 μ long, ca. 3 μ thick at the base and ca. 2 μ thick

near the apex. The apex is dilated, forming a collarette, and occasionally gives rise to a secondary proliferation.

The conidia are endogenous, hyaline, elliptical to ovoid, and ca. 4 x 3 μ. They are borne at the apex in one or two delicate cylindrical heads, up to 45 μ long, which fall away leaving a pair of conidia attached to the apex.

The chlamydospores are globose, thick-walled, sessile or almost so, and 5-6 μ in diameter.

Collected: Sinking Cr., poplar, trap C.

The collection answers van Beyma's (1940) description of this species.

Cacumisporium Preuss

Deutschl. Flora, Abt.III, Bandch. vi,
Heft 30, t. 43. 1851.

The conidiophores are dark, upright, septate, simple and bear an apical head of conidia.

The conidia are dark or hyaline, mostly 3-septate, oblong to fusoid, straight or curved. They are produced on a protruding, hyaline projection of the conidiophore. (Adapted from Barnett, 1960)

Cacumisporium sp.

(Fig. 13)

On wood this fungus is hardly visible to the naked eye, appearing as sparse, scattered, delicate conidiophores.

The conidiophores are straight, erect, septate, and dark brown becoming pale near the apex. From the apex protrude one or two hyaline sterigmata, ca. 10 μ long x 2 μ thick, with lateral teeth, on which are borne the conidia. The conidiophores are 255-450 μ long x 4.5 μ thick near the base, tapering to 3 μ thick near the apex.

The conidia are hyaline, ellipsoidal, slightly curved, guttulate, 3-septate, and 21-24 x 6-7 μ.

Collected: Claytor Lake, pine, trap A, poplar, trap B.

There is no recent revision of Cacumisporium, and its position seems indefinite. The genus is considered close to Acrothecium by Barnett (1960), but Ainsworth (1961) considers Acrothecium Sacc. a synonym of Cacumisporium Preuss. Gilman (1957) calls the genus Acrothecium Preuss, and Mason (1928) discusses the problem inconclusively. Our collection bears a close resemblance to an illustration of Cacumisporium tenebrosum by Hughes (1953). However, no description accompanies the illustration.

Dictyosporium Corda

Weitenw. Beitr. Nat., 1: 87. 1836.

The conidia are effuse or in sporodochia.

The sterile hyphae are within the substratum or sparse on the surface. They are effuse, hyaline to dark-colored, septate, and branched.

The conidiophores are reduced to very short branches on the assimilative hyphae. Conidial branches are formed by the division of the terminal cell of the conidiophore in a cell by cell manner.

The branches of the conidia are multicellular, arising (for the most part) from a single basal cell, although sometimes obscurely so; fusing laterally or not at maturity. The branches are more or less parallel, usually constricted at the septa, and rarely slightly incurved at the tips. Mature conidia are flat, dark-colored, usually U-shaped. (Adapted from Damon, 1952)

Dictyosporium elegans Corda
Weitenw. Beitr. Nat., 1: 87. 1836.
(Fig. 3)

The colonies occur on wood as dark, flat, irregularly shaped sporodochia. They are up to 0.5 mm. across and are often grouped as patches up to 4 mm. across.

The conidia are brown, flat or cylindrical, U-shaped, 39-102 x 20-34 μ, 1.5-3 times as long as wide, and have 5 or 6 branches. The branches arise simultaneously, are parallel, and do not separate. Each branch has 9-20 septa and is constricted at the septa.

Collected: Sinking Cr., poplar, trap B; Sinking Cr., wood debris, trap E; Claytor Lake, poplar, traps A and B; Tom's Cr., poplar, traps A and B.

Damon (1952) describes seven valid species of Dictyosporium. Two of these, D. elegans and D. zeylanicum, have flattened conidia with

distinct, non-separating branches. The latter is sporodochial, but its conidia are described as never cylindrical, with a maximum of 5 branches, each branch with less than 10 septa, and with maximum conidial dimensions of 40 x 25 u. His description of D. elegans neither includes nor rules out the sporodochial habit. Furthermore, the conidia of the latter species are both flat and cylindrical and have a size of 25-86 x 8-41 u.

The marked difference in shape, size, septation and branching of conidia seems too great to justify calling our collection D. zeylanicum merely on the basis of sporodochial habit. Our collection fits the description of D. elegans except in size of conidia, those of the latter being somewhat smaller. However, the size ranges of both are large and greatly overlap, so considerable variation in size from one collection to another is to be expected. Since the description of D. elegans does not rule out the sporodochial habit, our collection is considered to be this species.

Dictyosporium sp.
(Fig. 4)

On wood the fungus appears as irregular, brown patches of conidia.

The conidia are ellipsoidal, brown, flat, and 3-branched. The branches arise simultaneously, have incurved tips, and are laterally fused; they are 1-3-septate and unconstricted at the septa. The conidia are 19-33 μ long, 14-18 μ broad, and 5-7 μ thick.

Collected: Mountain Lake, poplar, trap A.

This collection resembles D. zeylanicum but does not exhibit the definite sporodochial habit described by Damon (1952). It is considered separate from our collection of D. elegans because the smaller 3-branched conidia are distinctly different. Furthermore, no conidia transitional in form were observed, and the two kinds of conidia were never seen in the same collection.

Gonytrichum Nees ex Wallroth
Flora Cryptogamica Germaniae, 2: 274. 1833.

Main stalks of the conidiophores are unbranched, straight or geniculate, bearing, below each of a number of septa, single, collar-like hyphae from which primary lateral branches arise either along the length of the main stalk or just toward the distal end; lateral branches may be absent altogether. Secondary, tertiary and even quaternary lateral branches, when present, develop in the same way from collar-like hyphae. Conidiophores may thus appear arborescent or more or less simple with or without lateral branches above. The ends of the main stalk and the laterals are usually sterile.

Phialides are produced from the collar-like hyphae and are more or less flask shaped with a well marked collarette.

The phialospores are subglobose to oval, slimy, continuous, hyaline to pale brown. (Adapted from Hughes, 1951a)

Gonytrichum macrocladum (Sacc.) Hughes
Brit. Mycol. Soc. Trans., 34: 566. 1951.
(Fig. 22)

The colonies on wood are effuse and olivaceous.

The mycelium is mostly immersed and composed of subhyaline to brown, branched, septate hyphae 2-3 μ wide.

The conidiophores are crowded but arise singly, and each is composed of a simple erect main stalk which is 250-360 μ long, septate, dark brown, swollen to 5-8 μ at the base, then 4-6 μ wide and tapering subulately and becoming paler towards the 1-1.5 μ wide apex. Indirectly on the lower half of the conidiophore, at nodes at intervals of between 18-40 μ, are borne four to eight whorls, each with up to six phialides; above are borne, also indirectly, one to three whorls of one to four divergent setae, although these may be absent. These whorls of phialides and setae are borne on brown septate hyphae which arise singly below a septum and which closely encircle the main stalk of the conidiophore.

The setae are brown below and taper subulately towards a hyaline often uncinate apex. They are 70-170 μ long and are directed upwards at an angle of about 45-80° to the main stalk.

The phialospores (conidia) are oval, continuous, subhyaline to very pale olivaceous, sometimes inconspicuously flattened at one end, 3.5-4.5 x 2.5-3.5 μ, produced in a slimy mass at the apex of the phialides or in a straight or curved column two or three conidia wide. (Modified from Hughes, 1951a)

Collected: Sinking Cr., poplar, trap B.

The description of Hughes (1951a) has been modified just slightly. Maximum conidiophore length has been increased from 320 μ, and phialospore dimensions have been increased from 3.5-4.5 x 2-2.5 μ.

Humicola Traaen

Nyt Mag. Naturv., 52: 31. 1914.

The hyphae are branched, decumbent or erect, hyaline, and septate. The conidiophores are short or long. The conidia are globose, ellipsoidal or ovoid, acrogenous, somewhat catenulate, and rarely intercalary. (Adapted from Johnson and Sparrow, 1961)

Humicola sp.

(Fig. 15)

The colony appears on wood as a tan, spongy heap of conidia (aleuriospores).

The aerial hyphae are tangled, brown, septate, 2.5-3.5 μ thick.

The aleuriophores are hyaline, ca. 3 μ long x 3 μ thick, each bearing a single aleuriospore at its apex. They separate easily from the mycelium and remain attached to the aleuriospores.

The aleuriospores are subhyaline, unicellular, obovoid, and uniformly 12 μ long x 9 μ broad. The wall is smooth with a double contour and a pore at the base.

No phialospores are evident.

Collected: V.P.I. Duck Pond, poplar, trap B.

The genus Humicola was established by Traaen (1914) with two species, H. grisea and H. fuscoatra, the two species differing primarily in size and color of the aleuriospores. There is some confusion in the definition of these differences (Mason, 1937; White and Downing, 1953), and the position of Humicola relative to that of Monotospora is not definite

(Mason, 1937, White and Downing, 1953 and Gilman, 1957). Therefore, our collection has not been identified to species.

Leptographium Lagerb. and Melin
Sven. Skogs. Tids., 25: 257. 1927.

The conidiophores are upright and branched penicilliately, terminating in slender phialides. The lower portion is dark but variable in shade; upper branches are hyaline.

The conidia are hyaline, ovoid, and held together in rather large heads by a mucilaginous substance. (Adapted from Barnett, 1960)

Leptographium sp.
(Fig. 12)

The fungus appears on wood as scattered conidiophores, often associated with blue-staining of the wood. The hyphae are not seen.

The conidiophores are upright, septate, branched up to 4 times; dark brown at the main stalk, paler at the lower branches, and hyaline at the phialides. They are 140-195 μ long with branching restricted to the upper portion. The base is 7-9 μ thick, tapering to ca. 4.5 μ at the lower branches, to ca. 1 μ at the phialides. The phialides are up to 22 μ long and bear a single conidium.

The conidia are hyaline, elliptical to ovoid, 1-2-celled, 4-6 x 9-15 μ.

Collected: Tom's Cr., pine, trap B.

Lagerberg, Lundberg, and Melin (1927) originally described the conidia of Leptographium as 1-celled. Elliot (1926) described Scopularia venusta with septate conidia. Shaw and Humbert (1952) consider Scopularia a synonym of Leptographium but do not regard Elliot's species to belong to Leptographium on account of the septate conidia. Our collection has both aseptate and septate conidia borne on the same conidiophore. The unique branching of the conidiophores is identical to that of Leptographium (Barnett, 1960, Davidson, 1955, Lagerberg et al., 1927, Shaw and Humbert, 1952, Elliott, 1926). Therefore our collection is considered Leptographium, in spite of its commonly septate conidia.

Monotospora Sacc.
Mich., 2: 25. 1882.

The mycelium is dark.

The conidiophores are dark, erect, slender, septate, simple, bearing a conidium terminally. Other conidia are sometimes attached laterally.

The conidia are large, 1-celled, ovoid to ellipsoidal. (Adapted from Barnett, 1960)

Monotospora megalospora Berk. & Br.
Ann. Mag. Nat. Hist. (Ser. 2), 13: 462. 1854.
(Fig. 19)

On wood and bark the conidiophores are erect, scattered or more usually in fascicles of 2-5; simple, brittle, straight of curved, but

not obviously geniculate. They taper slightly from a black opaque, often rooted, base to a yellow-brown apex. They are septate, rarely found bearing more than one conidium at the apex, 300-380 μ long, 9-12 μ thick at the base, and 6-7 μ thick at the apex.

The conidia are predominately obovate; with a truncate base, 5 μ broad and sometimes projecting. The conidial wall is thick, smooth, and shiny; yellow-brown at first, then opaque black. The conidia are ca. 35-45 μ long x 30-40 μ broad. (Modified from Mason, 1941)

Collected: Mountain Lake, pine, traps A and B; Tom's Cr., poplar, trap A.

Modification of Mason's description involves a change in dimensions. As given in his description, conidiophores are 140-380 μ long, 9-12 μ thick at the base, and 6-9 μ thick at the apex; conidia are 15-35 x 13-24 μ. The greater size of conidia in our collection may be partly due to swelling. When mounted in Ammon's medium, most of the conidia ruptured. Even so, the conidia of this collection, in their natural state, were probably as large as those of M. megalospora, the "large-spored Monotospora", (i.e., 0.035 mm. long) as described by Cooke (1871).

Piricauda Bubak
Ann. Myc., 12: 217. 1914.

The colonies are micronemic, at maturity sometimes consisting of a crust of crowded conidia.

The conidiophores generally arise directly from the substrate. They are simple, unbranched, and composed of several cells; or else they are reduced to a simple peg.

The conidia are phaeodictyous, monacrogenous, echinulate or smooth, and range in shape from sphaerical to elliptical to cylindrical to obspathulate to obovate to pyriform. They are pauci - (less than 10) to multilocular with cells regular or irregular in shape and have thin or thick walls. Disrupted sessile spores are frequently subtended by a torn remnant of fertile hyphae. (Adapted from Moore, 1958)

Piricauda sp.
(Fig. 18)

The colony appears on wood as scattered or crowded, black shiny conidia. On agar the colony is dark green with an inner brown ring. Hyphae on agar are fuscous to light brown.

The conidiophores are septate, often constricted at the septa, fuscous to dark brown, 4-12 μ long, 3.5-4 μ thick at the base, and 6-7 μ thick at the apex.

The conidia are light brown to opaque, subglobose to obovoid or irregular, crenate or regular, and have rough walls. Mature dark conidia are 18-21 x 18-54 μ and are composed of about 15-20 cells.

Chlamydospores develop on agar from intercalary swellings of the hyphae. They are light to dark brown, muriform, variable in shape and size, often as large as the conidia.

Collected: V.P.I. Duck Pond, pine, trap B; Sinking Cr., pine, trap D.

Moore (1958) emended the genus Piricauda Bubak to include species that had previously belonged to the genera, sensu Saccardo, Sporidesmium and Stigmella. Moore (1959) then presented a monograph of the species considered to fall within this re-established concept of Piricauda. However, the position of Piricauda is still far from definite (Moore, 1959; Hughes, 1960), so it is not surprising that our collection could not be identified to species.

Septonema Corda
Icones Fungorum, 1: 9. 1837.

The conidiophores are dark, simple or branched, tall or short and bear conidia apically.

The conidia are subhyaline to dark brown, typically 3- or several-celled, cylindrical to fusoid. They are catenulate, produced acropetally. (Adapted from Hughes, 1960)

Septonema hormiscium Saccardo
Michelia, 2: 559. 1882.
(Fig. 20)

The colonies are extensive; conidiophores and conidia are usually crowded, but sometimes scattered, appearing as black shiny sticks on the wood surface.

The mycelium is immersed in wood and is composed of pale brown hyphae. Hyphae in agar culture are 2 μ in diameter, swelling to 3.5 μ at point of conidiophore attachment, and are well-branched.

The conidiophores are more or less erect, straight or slightly curved, broadly fusoid, truncate above, irregularly shaped below, dark brown, thick-walled, smooth, with five to eight transverse septa, not constricted at the septa; they measure 34-42 x 10-13.5 μ and are very similar to the conidia; the flat apical scar is 4.5 μ wide.

The conidia are borne in a single, simple, acropetal chain of either three or four conidia at the apex of each conidiophore. The chains are straight and at maturity either fragment into the conidia or separate from the conidiophores and remain intact. At maturity the conidia are fusoid, with truncate or almost parallel-sided ends, often more tapered above than below, with a flat scar 4.5-6 μ wide at each end, except the terminal conidium of a chain which bears a scar only at the base; they are very dark brown with a thick outer wall and six to eleven thick-walled transverse septa. The conidia measure 40-60 μ x 7-11 μ. Each cell of a conidium contains a large globule. The basal conidium is broader and usually has more septae than the other conidia. The terminal conidium is often poorly developed, consisting of one or two septae and measuring 2-3 x 17-30 μ.

In a few cases, both conidia and conidiophores are full size, yet are non-septate except where they are attached to each other. (Modified from Hughes, 1952a)

Collected: V.P.I. Duck Pond, pine, trap B; Sinking Cr., pine, trap D; Claytor Lake, pine, trap A, poplar, trap B; Tom's Cr., poplar, trap B.

The description of Hughes (1952a) has been modified only slightly. The conidiophore dimensions he gives as 32-46 x 10-14 μ. In addition,

he describes the chain of conidia as containing at least four conidia, but does not indicate whether this includes the poorly developed terminal end as a separate conidium. The longitudinal walls, described as developing in occasional conidia, were not observed in our collection. His description makes no reference to the occasional non-septate conidia and conidiophores as observed in this collection.

Septonema secedens Corda
Icones Fungorum, 1: 9. 1837.
(Fig. 21)

The colonies appear on wood as caespitose patches, up to 7 mm. high, consisting of crowded conidiophores and tangled chains of catenulate conidia.

The mycelium is composed of subhyaline to brown, smooth-walled, septate, branched hyphae, 1.5-3.0 μ in diameter.

The conidiophores arise singly or less frequently in groups of four or five and are crowded, forming caespituli. They arise from upturned hyphae or more usually as upright lateral branches of repent hyphae. They are erect, more or less straight, simple or rarely forked at the base, septate with cells 18-25 μ long, subhyaline to pale brown, more or less cylindrical, 4-5 μ in diameter, and up to 200 μ long with a dark brown basal cell.

The conidia are borne in acropetal chains. At maturity they break apart readily, and the resulting conidia are oblong-ovoid or oblong to cylindrical, generally a little wider at the upper end, and very slightly waisted in the middle, with a slightly raised flat scar at each otherwise

more or less rounded end, thick-walled, with 3-many, mostly 5-7, transverse walls, smooth, not constricted at the septa, pale brown to olivaceous-brown, 7-8 x 28-70 μ. mostly 28-42 μ. Conidial initials appear as blown-out ends of terminal conidia. (Modified from Hughes, 1951)

Collected: Poverty Cr., pine, trap A.

Hughes (1951, 1952) describes five species of Septonema. Our collection fits most closely his description of S. secedens. This determination was based largely on conidial characteristics, because vegetative hyphae and conidiophores are scarce in our collection. There are several differences in the described conidial characteristics. Hughes describes conidia of S. secedens from Corda's (1837) original collection and from recent collections from England, as 3-septate and 18-23 x 6-6.5 μ. In contrast, the conidia from our collection, as described above, are always larger, usually have more transverse walls, and vary greatly in both size and number of septae.

Sporidesmium Link ex Fries
Systema Mycologicum, 3. 1832.

The colonies are usually effused, brown, gray, or black. The mycelium is superficial and/or immersed and non-hyphopodate. Setae are absent.

The conidiophores arise singly or in fascicles, usually terminally or laterally on the hyphae, but occasionally from cells of a flattened plate or stroma. They are brown or dark brown, often with successive terminal proliferations.

The conidia are formed singly as blown-out ends at the apices of the conidiophore and successive proliferations. They are obclavate, fusiform, conical, obpyriform, or cylindrical; often rostrate; straw colored to very dark brown; smooth or verrucose; and transversely septate or pseudoseptate. (Adapted from Ellis, 1958)

Sporidesmium caespitulosum (Ell. and Ev.) M.B. Ellis
C.M.I. Pap., 70: 40. 1958.
(Fig. 2)

The colonies on wood are black, tufted or subeffused. The mycelium is partly superficial but mostly immersed in the substratum. The hyphae are branched, septate, brown, smooth-walled, and 2-4 μ thick.

The conidiophores arise terminally and laterally on the hyphae, occasionally singly but usually in large fascicles. They are erect or suberect, simple, straight, mid to dark reddish brown, smooth-walled, non-septate, 12-15 μ long, bulbous and 8-11 μ thick at the base tapering to 4-6 μ at the apex.

The conidia are formed singly at the apex of each conidiophore. They are straight or occasionally bent or curved, cylindrical to sub-fusiform, truncate or conico-truncate at the base, smooth-walled, dark reddish brown, with 8-20 very dark transverse septa. The conidia are 65-150 μ long, 13-17 μ thick in the widest part, sometimes tapering to 8-10 μ near the rounded apex, 4-6 μ wide at the base. Average distance between the septa is 8.4 μ. (Adapted from Ellis, 1958)

Collected: Mountain Lake, poplar, trap A.

The description of Ellis (1958) fits our collection in all particulars and is adapted without change in substance.

Sporidesmium anglicum (Grove) M.B. Ellis
C.M.I. Mycol. Pap., 70: 60. 1958.
(Fig. 1)

The colony appears on wood as scattered, black conidia and conidiophores.

The conidiophores are single or fasciculate, erect or suberect, simple, straight or slightly flexuous, mid to dark reddish brown, 1-7-septate, and 50-115 μ long x 4-8 μ thick.

The conidia are formed singly at the end of each conidiophore. They are straight or flexuous, obclavate, rostrate, conico-truncate at the base, often constricted at the septa, smooth-walled, mid to dark reddish brown with the upper cells pale. The conidia are up to 525 μ long, 11-14 μ thick in the widest part, tapering to ca. 7 μ thick near the rounded apex, and ca. 5 μ thick at the base. There are up to 105 septa, averaging 5 μ apart. (Modified from Ellis, 1958)

Collected: Big Stoney Cr., poplar, trap A.

The description of Ellis requires modification only in dimensions and septation of conidia. These are described as 90-600 μ long, 12-16 μ thick at the widest part, tapering to 4-9 μ thick near the rounded apex, 5-6 μ thick at the base, septa averaging 4.4 μ apart. These differences hardly detract from the extremely long, rostrate conidia as an identifying feature of this species.

Sporoschisma Berkeley and Broome
Gard. Chron., 540. 1847.

The conidiophores are dark, upright, stout, simple, bearing conidia endogenously. The conidia are dark, 3- or more-celled, cylindrical, sometimes in chains. The fungus is saprophytic on decaying vegetation. (From Barnett, 1960)

Sporoschisma saccardoi Mason and Hughes
C.M.I. Mycol. Pap., 31: 20. 1949.
(Fig. 11)

The colonies appear on wood as shiny, velutinous mats of tangled, procumbent and prostrate chains of conidia which arise from sparse tufts of erect conidiophores.

The mycelium is composed of immersed, pale brown to dark brown hyphae, 2.5-4 μ in diameter.

The conidiophores are up to 210 μ long and have a dark brown color which becomes paler at the torn apex. The greater part of the conidiophore is almost cylindrical, 14-17.5 μ thick at the torn opening and 10-14 μ thick below. When it bears the characteristic swelling, this is up to 21 μ thick tapering more or less gently to a stalk, which may be 1 or 2-septate, 10-13 μ thick just above the basal swelling, which is up to 21 u thick.

Conidia are formed inside the base of the cylindrical part of the conidiophore, and they emerge in a single chain. They are cylindrical, 5-septate, with the four inner cells dark brown and the two end cells much paler, shorter, and somewhat truncate, giving the appearance of a

constriction between successive conidia of an unbroken chain. Dimensions of the conidia are 32-48 x 10-14 μ. Shorter conidia with 1 to 4 septae can be seen within, and emerging from, the conidiophore.

The capitate hyphae are brown below and paler above, straight or slightly bent, 2- to 4-septate below, up to 150 μ long, 5-6.5 μ thick at the base and 4.5-5 μ thick just below the terminal swelling which is 6-8 μ wide and subhyaline at its extremity. This swelling often has a hyaline envelope and is often collapsed at the thin-walled apex. (Modified from Hughes, 1949)

Collected: Sinking Cr., poplar, trap B; Tom's Cr., poplar, trap A.

In the species description of S. saccardoi, as given by Hughes (1949), the conidiophores differ slightly from those of our collection. They are always uniseptate and are slightly narrower in all dimensions, that is, 12-15 μ thick at the torn opening and 9-13 μ thick below, up to 17 μ thick at the characteristic swelling, and 7-10 μ thick at the basal swelling, which is 10-16 μ thick. Also Hughes' description makes no mention of the small, 1- to 4-septate conidia found in our collection. However, these conidia may be immature since they are seen only within, and emerging from, the conidiophore. Our collection fits his description in all other respects.

Trichocladium Harz

Bull. Soc. Imp. Moscow, 44: 125-127. 1871.

The conidiophores are short and poorly differentiated. Each conidiophore swells out at the apex into a solitary, dark brown, thick-

walled, oval conidium with 1-4 transverse septa. (Adapted from Hughes, 1952)

Trichocladium opacum (Corda) Hughes
Brit. Mycol. Soc. Trans., 35: 154-155. 1952.
(Fig. 17)

The colonies appear on wood as effuse but crowded, shiny black, nearly sessile conidia.

The hyphae, which are sparse on wood, are pale brown and measure 2-4 μ in diameter.

The conidiophores are unicellular, pale brown, 7-9 μ long, 4-5 μ thick at the bulbous base, and 2-3 μ thick at the truncate apex.

The conidia are obovoid to slightly pyriform, 4-septate, and have thick, smooth walls. regular to slightly constricted at the septa. Color of each conidium varies in shade from pale brown at the base to opaque at the apex. They are 28-37 x 14-18 μ. (Modified from Hughes, 1952)

Collected: Claytor Lake, pine, trap A.

In his description of this species Hughes (1952) describes the conidia as oval, elliptical, or clavate in shape and 20-40 x 10.5-16 μ in size. That is, the conidia are more variable in shape and not quite as broad as those of our collection. The collection fits his description in all other respects.

Unknown
(Fig. 16)

The conidia are pale brown, navicular, 6-7 septate, with little or no constrictions at the septa. They are 35-53 x 5-7 μ.

Collected: Claytor Lake, pine, trap A.

This collection contained only conidia and therefore could not be identified. The conidia resemble those of Cercospora or Cercosporella (Johnson and Sparrow, 1961).

Family: Moniliaceae

Arthrobotrys Corda
Prachtfl., 21. 1839.

The conidiophores are elongated, septate, slender, simple, slightly inflated at the apex and, typically, at "joints" below the apex.

The conidia are hyaline, unequally 2-celled, ovate-oblong, and are borne in loose clusters on warts or sterigmata on slightly enlarged portions of the conidiophore. (Adapted from Barnett, 1960)

Arthrobotrys sp.
(Fig. 25)

The conidiophore is hyaline, septate, 150 μ long x 2 μ thick, swollen at the apex and again 10 μ below it.

The conidia are borne on sterigmata, which protrude from the swellings of the conidiophore. They are hyaline, uniseptate, elliptical-

slightly obovoid, almost equally 2-celled, with the distal cell barely larger. The conidia are 14-17 x 4-5 μ.

Collected: Big Stoney Cr., wood debris, trap B.

This collection consists of one complete conidiophore and several conidia, hardly sufficient for identification to species. However, the small, almost equally 2-celled conidia suggest A. cladodes or A. superba (Dreschler, 1937).

Clathrosphaerina van Beverwijk
Brit. Mycol. Soc. Trans., 34: 289. 1951.

The fungus is aero-aquatic with a hyaline, branched, septate mycelium. The conidium is a hyaline, multicellular, sphaerical network produced by repeated forking and meeting of fork tips. (Adapted from van Beverwijk, 1951)

Clathrosphaerina zalewski van Beverwijk
Brit. Mycol. Soc. Trans., 34: 289. 1951.
(Fig. 26)

The fungus is aero-aquatic with a hyaline, branched, septate mycelium. Hyphae are 1-2 μ thick, and the conidiophore is a simple branch of the mycelium.

The conidia are produced above the water-level. The conidium is a hyaline, multicellular, spherical network, 18-25 μ (15-40 μ), produced by repeated forking and meeting of fork tips. The meshes of the network are surrounded by triangular or three-armed cells, 1.5-3 μ broad.

Each cell of the spore is capable of developing a germ tube. On decaying plant material in water. (Adapted from van Beverwijk, 1951)

Collected: Big Stoney Cr., wood debris, trap B.

The unique hyphal network of the spore of this fungus leaves no question of identity.

Fusarium Link
Berl. Mag., 3: 10. 1809.

The mycelium is extensive and cottony in culture, often with some tinge of pink, purple, or yellow in the mycelium or medium.

The conidiophores are variable; slender and simple; stout, short and branched irregularly; or bearing a whorl of phialides. They may be single or grouped into sporodochia.

The conidia are hyaline and variable, principally of two kinds; macroconidia and microconidia. The macroconidia are several-celled, slightly curved at the pointed ends, and typically canoe-shaped. The microconidia are 1-celled, ovoid or oblong, and borne singly or in chains. Some conidia are intermediate, 2- or 3-celled, oblong or slightly curved. The conidia are often held in a mass of gelatinous material. (Adapted from Barnett, 1960)

Fusarium solani (Martius) Appel and Wollenweber
Arb. K. Biol. Anst. Land-Und Forstw., 8: 1-207. 1910.
(Figs. 27, 28, 29)

The fungus appears on wood as white to tan to dark brown pionnotes, or sporodochia.

The conidiophores are stout, branched, ca. 30-40 μ long and 3 μ thick.

The conidia are white en masse. The macroconidia are allantoid, 4.5-6 x 41-47 μ, and 3-septate (rarely 4) with the wall dilated at the septa. The microconidia are ovate to ellipsoidal, often slightly pedicillate, unicellular, and ca. 3 x 6-7 μ. A few intermediate 1- and 2-septate conidia are present.

The chlamydospores are subglobose, smooth-walled, light brown, 7-15 μ, and occur singly or in chains of several.

Collected: V.P.I. Duck Pond, pine, trap A; Tom's Cr., pine, trap A; Poverty Cr., pine.

The species of Fusarium are poorly defined and exhibit many intermediate varieties (Gilman, 1957). Our collection is identified as F. solani on the basis of ovoid-ellipsoidal microconidia, presence of chlamydospores, and macroconidia that are allantoid, strongly 3-septate, and more than 40 u long.

Fusarium sp.
(Fig. 30)

The macroconidia are fusiform, straight or slightly curved, and often slightly obtuse at one end. They are 3-septate, 4-5 x 25-29 μ; or rarely aseptate, 3.5 x 23 μ; and are constricted at the septa.

Collected: Sinking Cr., poplar, trap B.

This collection, consisting only of macroconidia, is insufficient

for identification to species. It is mentioned here because the conidia differ from those of our collection of F. solani.

Helicomyces Link

Ges. Naturforsch. Freunde Berlin, Mag. 3: 21. 1809.

The conidia are hyaline, white to pinkish in mass, the filaments slender, hygroscopic, convolutely coiled forming a disk-shaped body. The conidiophores are present as teeth on the repent mycelium or as short erect, hyaline branches. The colonies are effuse (from Linder, 1929).

Helicomyces roseus Link

Ges. Naturforsch. Freunde Berlin, Mag. 3: 21. 1809.
(Fig. 9)

The colonies are effuse, forming a thin flocculose white to pinkish layer.

The sterile mycelium is creeping, hyaline or occasionally dilute fuscous below.

The conidiophores are hyaline and arise from the repent mycelium as teeth or short, erect branches. Each conidiophore bears one conidium at its apex.

The conidial filaments are hyaline, white to pinkish in mass, multiseptate, and slender; 2.5-4.5 μ thick tapering to a terminal cell swollen at the base, which is generally slightly rounded and obliquely flattened. They are coiled in two dimensions, $2\frac{1}{4}$-3 times, with a coil diameter of 30-40 μ. (Adapted from Linder, 1929)

Collected: Claytor Lake, poplar, trap A; Poverty Cr., pine and poplar.

Hobsonia Berkeley
Ann. Bot., 5: 509. 1891.

The sporodochia are verriciform, gelatinous or dry and granular on the surface. Each conidium consists of a long stout multiseptate filament, which is coiled in three planes or irregularly in tangled knots. The conidia often proliferate. (Adapted from Linder, 1929)

Hobsonia mirabilis (Peck) Linder
Missouri Bot. Garden, 16: 340-341. 1929.
(Fig. 10)

The colonies on wood occur as groups of sporodochia, up to 1 mm. in diameter, which are often confluent as patches several millimeters across. They are tan to brown, have a granular surface, and become hard with age. There is no evidence of a gelatinous sheath.

The conidia are hyaline, irregularly coiled, multiseptate filaments, 12-14 μ thick at the septa.

Collected: Tom's Cr., poplar, trap A.

Linder (1929), in describing two species of Hobsonia, states that H. mirabilis differs from H. gigaspora in the non-gelatinous colonies of the former; its thicker conidial filaments, generally 12-15 μ thick; and the type of conidiophore branching. The conidiophores of our collection could not be examined as only a few short remnants could be seen within

the sporodochia. Therefore, the species identification is here based on the non-gelatinous sporodochia and the conidia dimensions.

Verticillium Nees

Syst. Pilz., 57. 1817.

The sterile hyphae are creeping, septate, branched, hyaline or lightly colored.

The conidiophores are erect, septate, and branched. Branches of the first order are whorled, opposite or alternate. Branches of the second order are whorled, dichotomous, or trichotomous on the branches of the first order. Further branching is similar. The terminal branchlets are usually flask-shaped and distinctly pointed at the apex.

Conidia are always borne singly on the branchlets, soon falling away. They are round, elliptical, ovate, obovate, or short spindle-shaped. The conidia are hyaline or slightly colored. (Adapted from Gilman, 1957)

Verticillium sp.

(Fig. 24)

The fungus appears on wood as a white or pale yellow crust of conidia.

The conidiophores are hyaline, erect, up to 300 μ tall, with whorls of slender branchlets. Secondary branchlets, when present, are usually stouter.

The conidia, formed at tips of the branchlets, are hyaline, ellipsoidal to slightly reniform, and 2-3 x 5-6 μ. Conidia are often held in mucilaginous drops.

Collected: Sinking Cr., poplar, trap B, pine, trap E; Poverty Cr., pine and poplar, trap A.

Species of Verticillium are determined according to color of the colonies, (Gilman, 1957). Since our collection exhibited both white and yellow colonies on wood, it could not be identified to species. Furthermore, the production of mucilaginous conidial heads is characteristic of Acrostalagmus, so our collection may belong to a species of that genus. Although Gilman separates the two genera, Acrostalagmus is a facultative synonym of Verticillium (Hughes, 1951). Therefore, our collection is placed in the latter genus.

Family: Tuberculariaceae

Bactrodesmium Cooke
Grevillea, 12 (no.61): 35. 1883.

The sporodochia are punctiform, brown or black. The mycelium is mostly immersed in the substratum, and stromata are absent or rudimentary.

The conidiophores are fasciculate and are usually formed at the ends of hyphae where these push through to the surface of the substratum. They are septate, simple or branched, hyaline to very pale brown, and narrow at the base, usually broadening somewhat towards the apex.

The conidia are always formed singly as blown-out ends at the apices of the conidiophores. They are septate, pale brown to very dark brown, and their basal cells are often much paler than the others. (Adapted from Ellis, 1959)

Bactrodesmium arnaudii Hughes
Canad. J. Bot., 36: 738. 1958.
(Fig. 23)

The colonies appear on wood as scattered, shiny, black sporodochia up to 500 u across. The mycelium is immersed in the wood.

The conidiophores are fasciculate, flexuous, subhyaline to pale brown, smooth-walled, septate, up to 35 μ long, and 3-4 μ thick.

The conidia are formed singly as blown-out ends at the apices of the conidiophores. They are smooth, clavate, rounded at the tip, and taper to a truncate base. Upper cells are light brown to opaque; lower cells are subhyaline to pale brown. The conidia are 4- to 5-septate, with thick black bands at the uppermost and penultimate septa of the darker conidia. Length of the penultimate cell is 1.5-2 times that of the terminal cell. The conidia are 39-49 μ long x 18-22 μ broad. (Modified from Ellis, 1959)

Collected: Mountain Lake, poplar, trap A; Claytor Lake, pine, trap B.

Ellis distinguishes nine species of Bactrodesmium by size, shape, and color of conidia; presence or absence of broad bands at the conidial septa; and relative length of the penultimate cell. This collection fits his description of B. arnaudii with some variation. He describes conidia as mid to dark brown at the upper cells with broad bands at the septa. Upper cells of our conidia vary from light brown without thick bands to dark brown with thick bands to opaque. These variations are

often found within one sporodochium and may represent stages in maturity of the conidia. In his description, conidia are 28-58 μ long x 15-23 μ broad; this encompasses the size range in our own collection. The hyphae and full-length conidiophores were torn away during transfer and could not be compared with the description. Relative length of the penultimate cell of B. arnaudii is not mentioned in Ellis' description but is shown in his illustration of this species and in his key to species of Bactrodesmium.

Therefore, this collection is identified as B. arnaudii on the basis of conidia, which are clavate, between 15 and 23 μ broad, and possess a relatively long penultimate cell.

Order: Sphaeropsidales

Family: Sphaeropsidaceae

Aposphaeria Berk.
Outl. Brit. Fung., 315. 1860.

The pycnidia occur on bark or wood and are superficial, or nearly so, when first formed. They are glabrous, asubiculate, papillate, globose or ovoid, and sometimes variable in shape. The texture is more or less prosenchymatous, becoming somewhat carbonaceous, generally hard and brittle.

The conidiophores are short (up to 10 μ), simple, and sometimes inconspicuous.

The conidia are oblong, ovoid, subglobose, or subfusoid; continuous and hyaline. (Adapted from Groves, 1935)

Aposphaeria agminalis Sacc.
Sacc. Syll., 3: 171. 1884.
(Fig. 33)

The pycnidia are superficial with the base flattened against the wood. They are black, papillate, hemispherical, 70-160 μ in diameter. The peridium is prosenchymatous and dark brown.

The conidiophore line the inner wall of the pycnidium and squeeze out as dense aggregates. They are obspathulate, ca. 8 μ long, 2 μ thick at the base, and 1 μ thick at the apex.

The conidia are hyaline, ellipsoidal, and ca. 1 x 2 μ.

Collected: Mountain Lake, pine, trap B; Tom's Cr., poplar, trap B.

The conidia and conidiophores of our collection are small and indistinct, defying detailed observation. Consequently, the description of these structures may be somewhat inaccurate. Species identification is based on the extremely small conidia (Groves, 1935).

Asteromella Pass. and Theum.
Myc. Univ. n. 1689. 1880.

The pycnidia are dark, small, globose, ostiolate, located on a mass of radiating dark hyphae.

The conidia are hyaline, 1-celled, ovoid to cylindrical. (Adapted from Barnett, 1960)

Asteromella sp.
(Fig. 32)

On agar the colony is grayish-green or grayish-brown with a floccose

mycelium. The hyphae are brown forming subicula in which are embedded the pycnidia.

The pycnidia are black, glabrous, globose, astromatic, ostiolate, and 100-300 μ in diameter.

No conidiophores are evident.

The conidia are held in a tan, sticky mass. They are unicellular, ovoid, subhyaline, 6-8 x 9-11 μ, and guttulate with many small droplets.

Collected: V.P.I. Duck Pond, poplar, trap B; Sinking Cr., poplar, trap B, pine, trap E.

This identification is based on the ostiolate, astromatic, non-beaked, complete, subiculate pycnidia and the unicellular, colorless conidia. However, on agar some pycnidia occurred free of a subiculum. Therefore, this identification is only tentative.

Coniothyrium Corda
Icones Fungorum, 4: 38. 1840.

The pycnidia are single or grouped, astromatic, subglobose or depressed, papillate and glabrous. The peridium is usually thin and membranous, rarely subcarbonaceous, and black.

The conidiophores are short, simple, and usually inconspicuous.

The conidia are small, globose to ellipsoidal, continuous, hyaline or pale at first, later olivaceous or fuscous to brown, most often uniguttulate, but sometimes biguttulate. (Adapted from Grove, 1937)

Coniothyrium sp.

(Fig. 31)

The pycnidia are globose or subglobose, astromatic, ostiolate, without a beak, glabrous, and 240-315 μ in diameter. The peridium is soft, membranous, light brown.

Conidiophores are not evident.

The conidia are abundant, completely filling the pycnidia. They are ellipsoidal, light brown, and ca. 2 x 5.5 μ.

Collected: Sinking Cr., poplar, trap B.

Grove (1937) separates 36 species of Coniothyrium according to hosts. There seems to be no monograph or classification of this genus based on characteristics of the fungus itself. Therefore, identification to species was not attempted.

Stagonospora Sacc.

Syll. Fung., 3: 445. 1884.

The pycnidia are immersed or half-projecting, globose or lens-shaped, astromatic, and usually pierced at the summit by a pore. The peridium is parenchymatous, thick or thin, usually formed of thin-walled cells, and is often darker around the pore.

The conidia are oblong-linear, fusoid, or ellipsoid; hyaline; guttulate and have two or more distinct septa. The guttules are often large. (Adapted from Grove, 1935)

Stagonospora sp. (1)
(Fig. 34)

The pycnidia are immersed and slightly erumpent, astromatic, dark brown, ostiolate, and globose with a diameter of ca. 275 μ. The centrum is guttulate.

Conidiophores are not evident.

The conidia are oblong with obtuse ends, hyaline, guttulate, and 3-septate (sometimes 4-septate). The walls are smooth and are not constricted at the septa. The conidia are 25-38 μ long x 6-7.5 μ thick.

Collected: Poverty Cr., poplar.

Species of Stagonospora are separated in large part according to occurrence on different host-genera of vascular plants (Grove, 1935). Cunnell (1956, 1957) defends this practice and also places great emphasis on conidial dimensions as criteria for separating species; he considers pycnidial characteristics of little value. The ranges of conidial dimensions of many species overlap and are poorly defined; Therefore species identification seems impossible without knowledge of the host-range. Since the host-range of our collection was not studied, the species name was not determined.

Stagonospora sp. (2)
(Fig. 35)

The pycnidia are black, astromatic, ostiolate.

The conidia are hyaline, ellipsoidal, 2-3-septate, guttulate, 3 x 8-10.5 μ. They separate easily from the conidiophores, which are gathered into rosettes.

Collected: Sinking Cr., Monocot debris, trap D.

This fungus is tentatively placed in Stagonospora on the basis of an apparently astromatic pycnidium and the hyaline 2-3-septate conidia. The collected material is not sufficient for a positive identification.

Class: Actinomycetes

Nocardia Trevisan

I Generi e le Specie Delle Batteriacee, Milan. 1889, 9.

The mycelium is formed of slender filaments or rods, which are frequently swollen and occasionally branched. Shorter rods and coccoid forms are found in older cultures. Conidia are not formed. The rods stain readily, occasionally showing a slight degree of acid-features. They are aerobic, gram-positive, non-motile, and do not produce endospores. (Adapted from Breed, Murray, and Smith, 1957)

Nocardia sp.

The mycelium appears on wood as loose white tufts or cushions. When placed in water the hyphae fragment into hyaline, rod-shaped oidia , ca. 2-10 x 1 μ.

Collected: Tom's Cr., poplar, trap B.

This organism was not identified to species, as it would have required studies in culture.

Class: Ascomycetes

Series: Pyrenomycetes

Nectria Fr.

Sum. Veg. Scan., 387. 1849.

The perithecia are free, cespitose, on a tuberculiform, carnose, conidial stroma, or scattered without any definite stroma. They are carnose-membranaceous, mostly bright colored, (red, etc.), smooth, subvillose, squamulose, etc..

The asci are cylindric-clavate, 8-spored, mostly without paraphyses.

The ascospores are oblong or elliptical, hyaline, uniseptate.

(Adapted from Ellis and Everhart, 1892)

Nectria sp.

(Fig. 36)

The perithecia are superficial, astromatic, subglobose to ellipsoidal, 110-250 μ in lateral diameter, ostiolate without papilla or beak, and often forming spherical buds or polyps at the base, especially on agar. They are usually scarlet; sometimes orange, dark red, or reddish-brown; with a glabrous, rough wall, with easily distinguished cells, collapsing laterally when dried. The centrum is greenish-yellow or yellow; and periphyes, also perhaps paraphyses, are present.

The asci are clavate, with a truncate apex, unitunicate, 70-90 μ long, ca. 6 μ thick at the base and apex, and ca. 9 μ thick at the middle. The ascospore arrangement is obliquely monostichous.

The ascospores are fuscous, ellipsoidal, equally 2-celled, unconstricted or slightly constricted, verrucose, 12-13.5 x ca. 6 μ. The immature ascospores are slightly smaller and hyaline.

The chlamydospores are spherical, fuscous, thick-walled, terminal, in chains of several, the largest 10 μ in diameter.

Collected: Sinking Cr., pine, traps B and D; Tom's Cr., pine, trap B.

Material from this collection was examined by Clark T. Rogerson, Curator of Cryptogamic Botany, The New York Botanic Gardens. He suggests the Episphaeria group of Nectria on the basis of small perithecia (less than 250 μ in diameter), lack of stroma, scarlet color, and lateral collapse when dry. Absence of mature ascospores prevented identification to species.

There are a dozen or more species in the Episphaeria group, of which N. flavo-viridia seems closest to our collection (Booth, 1959). However, positive identification seems to require examination of the conidial stages and cross-sections of the perithecial wall. Such studies were not attempted.

Unidentified Pyrenomycetes

The collections described below were observed on wood and then preserved as squash mounts. However, this material proved inadequate for proper study of the structures - periphyses, paraphyses, centria, peridia, stroma - upon which identification of Pyrenomycetes is largely based. Future collections must include cross-sections of perithecia, as recommended by Munk (1960). Each description is preceded by the original collection number.

1 (Fig. 44)

The perithecia are black, superficial, possibly erumpent, and rough-walled. The asci are clavate, curved, ca. 90 x 12 μ; and have a rounded, thick-walled apex. The ascospores are hyaline, fusiform, unequally 2-celled, 10-14 x 23-27 μ.

Collected: V.P.I. Duck Pond, poplar, trap A.

2 (Fig. 45)

The perithecia are black, partially immersed, ostiolate, without papilla or beak, membranous, and glabrous. The asci are oblong, 60-70 x 10-11 μ, thick-walled with 8 spores, arranged biserially. The ascospores are hyaline, fusiform, 4-celled, constricted at the middle septum, 11-14 x 23-27 μ.

Possibly identical to No. 1 but more mature.

Collected: V.P.I. Duck Pond, poplar, trap A.

4 (Fig. 43)

The perithecia are superficial, black, ostiolate, with hyphal appendages. The asci are oblong, thick-walled, 81-87 x 7-8 μ, with 8 ascospores. The ascospores are arranged biserially and are brown, fusiform, slightly curved, 4-celled, slightly constricted at the midseptum, with one cell adjacent to the midseptum usually larger than the others; they are 3-5 x 16-23 μ.

Collected; Sinking Cr., monocat debris, trap D.

6 (Fig. 39)

The perithecia are innate or erumpent, astromatic, aparaphysate, ostiolate, brown, membranous, 95-440 μ high, and 125-260 μ in diameter at the base. Asci have v-shaped apical apparatus with 2 refractive bodies; they have 8 spores in three series and are ca. 123 x 11 μ. The asci are deliquescent, and the spores emerge as a gelatinous mass, reddish-gray to yellowish to brown. The ascospores are cylindrical to slightly allantoid to slightly fusiform, with one end slightly more attenuated than the other, 6-celled, unconstricted, guttulate, subhyaline, 57-62 x 4.5-6 μ.

Collected: Sinking Cr., pine, trap E.

7 (Fig. 46)

The perithecia are immersed, arranged along the grain of the wood. The asci are thick-walled. The ascospores are 1- or 2-celled, elliptical, hyaline, guttulate, 16-18 x 3-4 μ, with 4 appendages at one end.

Collected: Sinking Cr., poplar, trap B.

20 (Fig. 42)

The perithecium is superficial, spherical, brown, 200-900 μ in diameter and contains no ostiole. The peridium is rough, fragile, glabrous; composed of angular, more or less square cells, 4.5-6 x 6-7.5 μ. The asci are deliquescent. The ascospores are unicellular, ellipsoidal, brown, guttulate, 15-17 x 8-9 μ, with a germ pore at one end.

Collected: V.P.I. Duck Pond, pine and poplar, trap A, pine and poplar, trap B; Sinking Cr., poplar, trap B.

29 (Fig. 40)

The perithecia are innate, astromatic, 300-500 μ in diameter, and have a prominent beak. The base is hyaline to light brown; the beak-tip is green, greenish—orange, red, or yellowish-brown. Cells of the peridium are variable, 7-15 μ. The asci are thin-walled, with an apical canal, 91-143 x 10.5-14 μ. The ascospores are 3- or 4-ranked, subhyaline, cylindrical to allantoid, 5-7-septate, unconstricted, 66-84 x ca. 4.5 μ.

This collection may be the same species as collection No. 6.

Collected: Sinking Cr., poplar, trap D.

32 (Fig. 38)

The perithecia are black, coriaceous, innate, with a prominent beak. The base is 225-450 μ in diameter; the beak is 120 μ thick at its base and 74 μ thick at its tan apex. The asci are deliquescent, 35-54 x 4.5 μ.

The ascospores are biseriate, hyaline, fusiform-slightly lunate, 4-celled, 15-22 x 3-4 μ.

Collected: Sinking Cr., monocot debris, trap D.

36 (Fig. 37)

The perithecia are black, flask-shaped, partially innate, coriaceous, ostiolate, aparaphysate, periphysate, 135-195 μ in diameter, with ostiole 30 μ in diameter. The asci are bitunicate, deliquescent, ca. 70 x 21 μ. The ascospores are biseriate, hyaline, ellipsoidal, uniseptate, constricted, guttulate, 25-31 x 7.5-9.5 μ.

Collected: Poverty Cr., pine.

46 (Fig. 41)

The perithecia are gregarious, black, subglobose, papillate, superficial, soft, compressing vertically when dried, 120-140 μ in diameter. The asci are thin-walled, 40-50 x 3-4 μ. The ascospores are biseriate, hyaline, 2-4-celled, ellipsoidal, slightly curved, 15-21 x 3-4 μ.

Collected: Sinking Cr., pine, trap E.

DISCUSSION - ECOLOGY

A comparison of the results of this study with the results of other investigations (cited below) on aquatic fungi indicates the existence of a distinct aquatic mycoflora associated with wood.

Aquatic Hyphomycetes have been extensively collected from submerged leaves (Petersen, 1962 and Ingold, 1942, 1943a, 1943b, 1944, 1949, 1958b) and from pond and stream scum (Ingold, 1956, 1958a, 1959). None of the species, not even the genera, of those collections have been found in the present survey.

Aquatic Phycomycetes grow on a vast array of substrates - fish, fish eggs, exuviae, fruits, seeds, cellulose products, etc. (Sparrow, 1960). In the present survey no Phycomycetes were found associated with wood, and Sparrow (1960) and Johnson and Sparrow (1961) do not report aquatic Phycomycetes from wood. Perhaps these fungi cannot utilize cellulose in wood because they have no way of breaking down the lignin associated with it.

Although found on wood, some of the fungi collected in the present survey may not be utilizing the lignin itself, but may instead be associated with other organisms and their metabolites on the wood surface. There may also be some association with the organic debris, such as insect eggs and detritus, which is often abundant on surfaces in the water. Barghoorn (1944) noted that marine fungi commonly become established on material covered by surface growths of various organisms, presenting upon decomposition a readily available supply of organic nitrogen.

However, since there seems to be a distinct lignicolous aquatic mycoflora, and since many aquatic fungi that are commonly found on leaves, cellulose, and other plant products are not found on wood, it is probable that many aquatic lignicolous fungi are associated with lignin itself. The role of aquatic lignicolous fungi in the decomposition of wood is poorly understood (Johnson and Sparrow, 1961, pp. 92-138), so further conjecture on the relationship between these fungi and wood is not justified.

The fresh-water population of lignicolous fungi may be fairly distinct from that of salt-water. Johnson and Sparrow (1961) have compiled a comprehensive list of fungi, including lignicolous forms, from marine environments. Only five of these fungi - Alternaria sp., Dictyosporium elegans, Humicola sp., Trichocladium sp., Coniothyrium sp., Nectria sp. - cam be considered closely related to fungi found in the present study. According to Johnson and Sparrow (1961) the above fungi are also found in brackish water, evidence that the two populations may not be entirely distinct.

Further evidence of a characteristic fresh-water population is given by Hughes (1960). Aquatic lignicolous fungi were collected from an estuary varying in salinity from fresh water to sea water. Twenty eight species of Ascomycetes and Deuteromycetes were collected at the fresh-water stations (0.0 to $\pm$ 0.5%). None of these species were among the 72 species collected from brackish water and sea water. Of the 13 species of Deuteromycetes from the fresh-water station, five have probably been found in our study - Dictyosporium elegans, Dictyosporium sp., Gonytrichum sp., Helicomyces roseus, Monotospora sp..

Gold (1959) collected 23 species of aquatic lignicolous fungi from an estuary, different from that of Hughes (1960), at stations of different salinities, including fresh water. The fungi showed a distributional propensity for one of three sections of the estuary: (1) eight species - fresh water; (2) eight species - salt water; (3) seven species - fresh, brackish, and sea water. The investigation also showed that temperature influences salinity tolerances of aquatic fungi. Most of the fungi collected were Ascomycetes and could not be compared with our collection, mostly comprising Deuteromycetes.

The foregoing review of pertinent literature, together with the present study, provides some insight into the ecology of the fresh-water lignicolous fungi. Perhaps the most important problem now is to determine the actual habitat of these fungi. Research so far indicates only that they grow on wood and that their spores are carried in the water. Another problem is to investigate the nutrition of these organisms, to determine if they digest lignin and if they are unique in this regard.

SUMMARY

Aquatic lignicolous fungi were collected from six aquatic sites in the area of Blacksburg, Virginia. The following fungi were identified and described:

Dematiaceae

Alternaria sp.
Bisporomyces chlamydosporis
Cacumisporium sp.
Dictyosporium elegans
Dictyosporium sp.
Gonytrichum macrocladum
Humicola sp.
Leptographium sp.
Monotospora megalospora
Piricauda sp.
Septonema hormiscium
S. secedens
Sporidesmium caespitulosum
S. anglicum
Sporoschisma saccardoi
Trichocladium opacum

Actinomycetes

Nocardia sp.

Moniliaceae

Arthrobotrys sp.
Clathrosphaerina zalewski
Fusarium solani
Helicomyces roseus
Hobsonia mirabilis
Verticillium sp.

Tuberculariaceae

Bactrodesmium arnaudii

Sphaeropsidales

Aposphaeria agminalis
Asteromella sp.
Coniothyrium sp.
Stagonospora sp. (1)
Stagonospora sp. (2)

Pyrenomycetes

Nectria sp.

Two unidentified Dematiacae and ten unidentified Pyrenomycetes were also collected and described.

The results of this study were compared with results from other investigations of aquatic fungi. This comparison was shown to indicate the existence of a distinct fresh-water lignicolous mycoflora.

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PLATE I

(The letter following each explanation refers to magnification scale.)

Dematiaceae

Fig. 1 *Sporidesmium anglicum*: conidiophore and conidium (b)

Fig. 2 *S. caespitulosum*: conidiophore and conidium (b)

Fig. 3 *Dictyosporium elegans*: conidia (b)

Fig. 4 *Dictyosporium* sp.: conidia (b)

Fig. 5 *Bisporomyces chlamydosporis*: conidiophore and head of conidia (c)

Fig. 6 *B. chlamydosporis*: conidiophore and pair of young conidia after head of older conidia has fallen away (c)

Fig. 7 *Alternaria* sp.: conidia (b)

Fig. 8 Unknown: conidiophore and conidium (c)

Helicosporous Moniliaceae

Fig. 9 *Helicomyces roseus*: hypha, conidiophore, and conidium (b)

Fig.10 *Hobsonia mirabilis*: conidia (b)

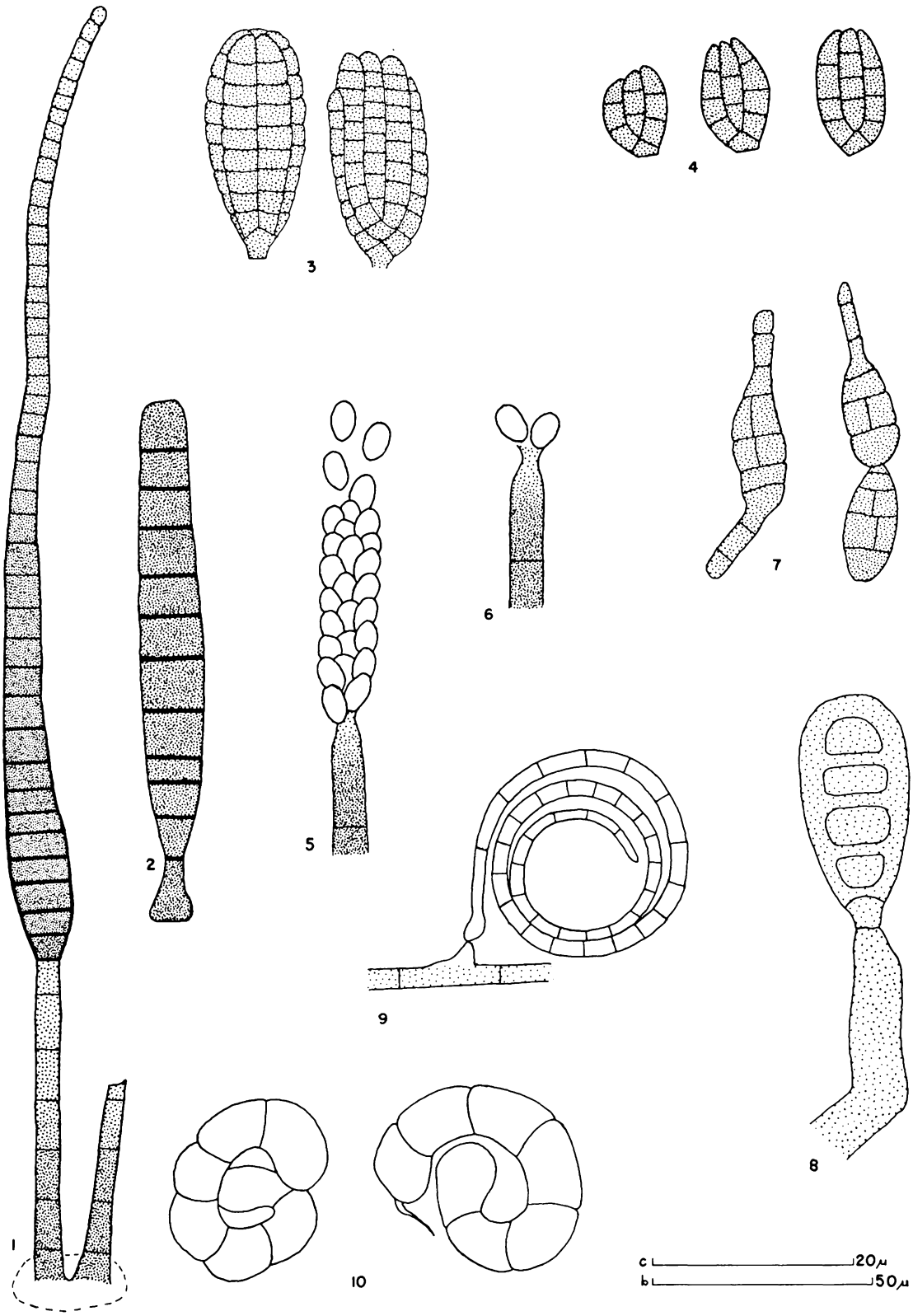
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PLATE II

(The letter following each explanation refers to magnification scale.)

Dematiaceae

Fig. 11 Sposchisma saccardoi: conidiophore and conidia (a)

Fig. 12 Leptographium sp.: portion of conidiophore and conidia (c)

Fig. 13 Cacumisporium sp.: upper portion of conidiophore and conidia (b)

Fig. 14 Cacumisporium sp.: upper portion of conidiophore and one conidium remaining after others have fallen away (c)

Fig. 15 Humicola sp.: aleuriospore (c)

Fig. 16 Unknown: conidium (c)

Fig. 17 Trichocladium opacum: conidiophores and conidium (b)

Fig. 18 Piricauda sp.: conidiophore and conidium (b)

Fig. 19 Monotospora megalospora: upper conidiophore and conidium (b)

Fig. 20 Septonema hormiscium: conidiophore and catenate conidia (b)

Fig. 21 S. secedens: conidia (b)

Fig. 22 Gonytrichum macrocladum: conidiophore and conidia (a)

Fig. 23 Bactrodesmium arnaudii: conidiophores and conidia (b)

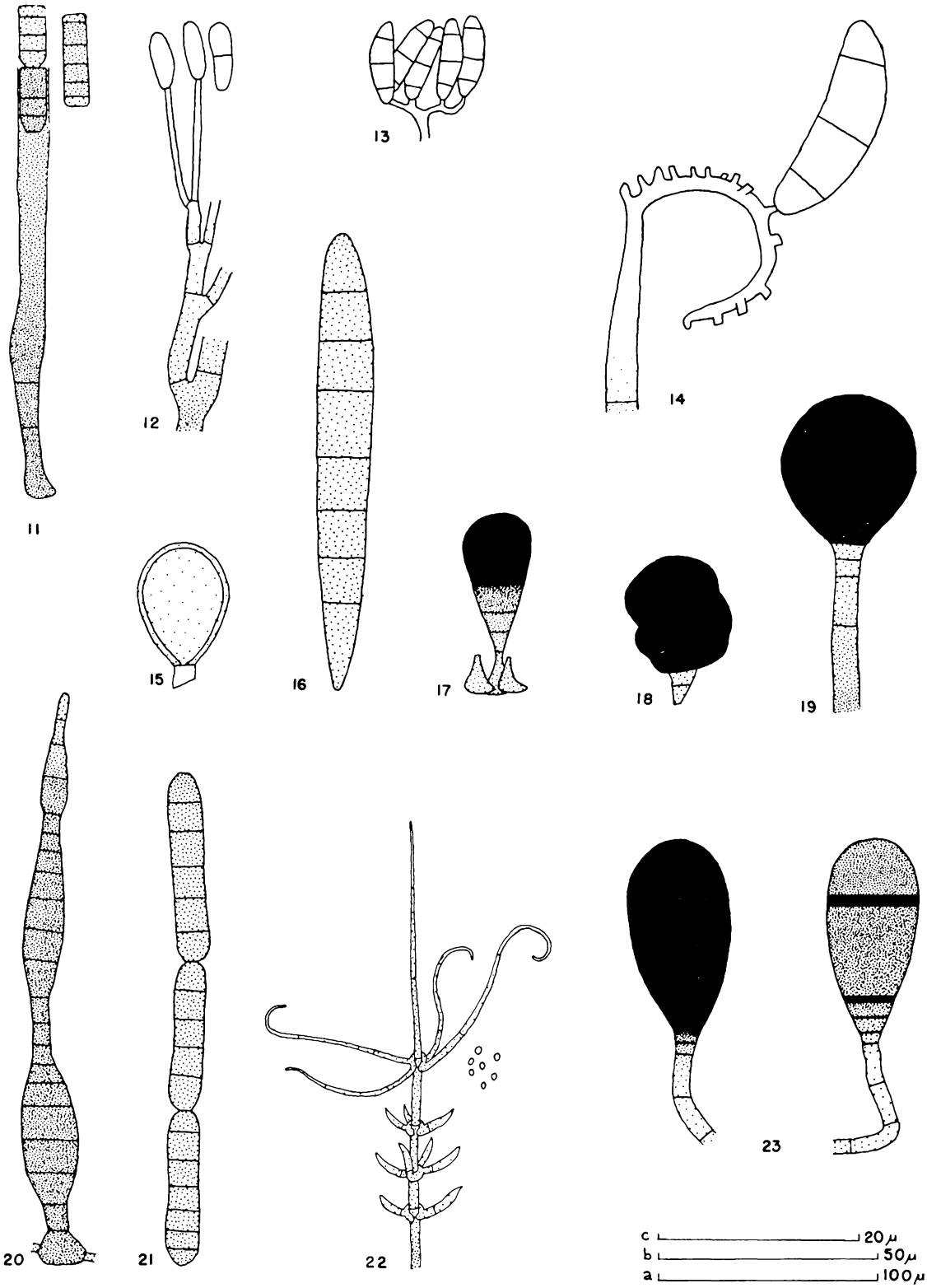
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PLATE III

Moniliaceae

Fig. 24 *Verticillium* sp.: portion of conidiophore and conidia

Fig. 25 *Arthrobotrys* sp.: portion of conidiophore and conidia

Fig. 27 *Fusarium solani*: chlamydospores

Fig. 28 *F. solani*: portion of a pionnote and microconidia

Fig. 29 *F. solani*: macroconidium, microconidia, and an intermediate conidium

Fig. 30 *Fusarium* sp.: macroconidium

Helicosporous Moniliaceae

Fig. 26 *Clathrosphaerina zalewski*: conidium

Sphaeropsidales

Fig. 31 *Coniothyrium* sp.: conidia

Fig. 32 *Asteromella* sp.: conidia

Fig. 33 *A. agminalis*: conidia

Fig. 34 *Stagonospora* sp. (1): conidia

Fig. 35 *Stagonospora* sp. (2): conidia

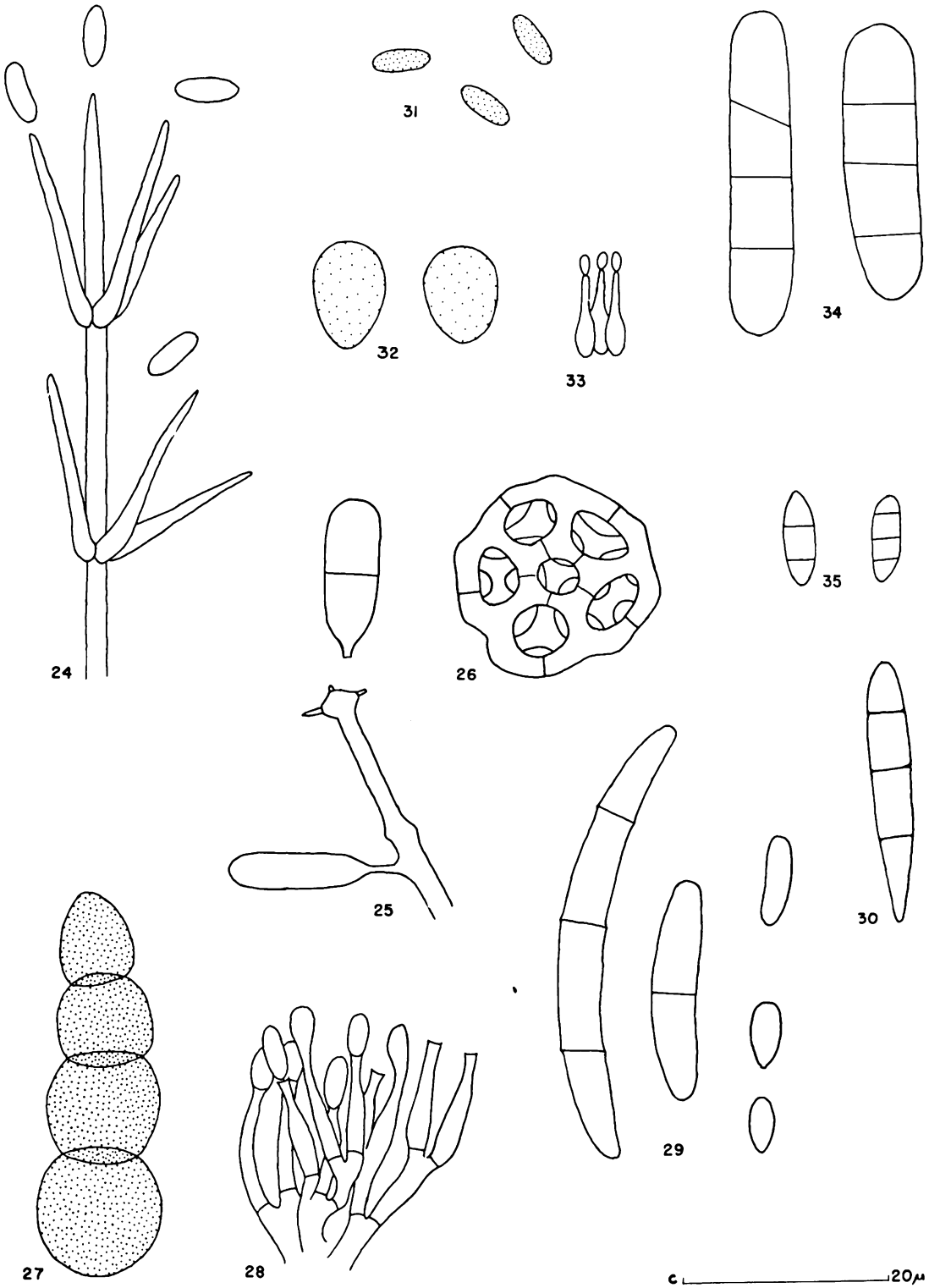
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PLATE IV

(The letter following each explanation refers to magnification scale.)

Pyrenomycetes

Fig. 36 Nectria sp.: ascus with ascospores (d)

Fig. 37 # 36: ascospore (c)

Fig. 38 # 32: ascospores (c)

Fig. 39 # 6: ascospore (c)

Fig. 40 # 29: ascospore (c)

Fig. 41 # 46: ascospores (c)

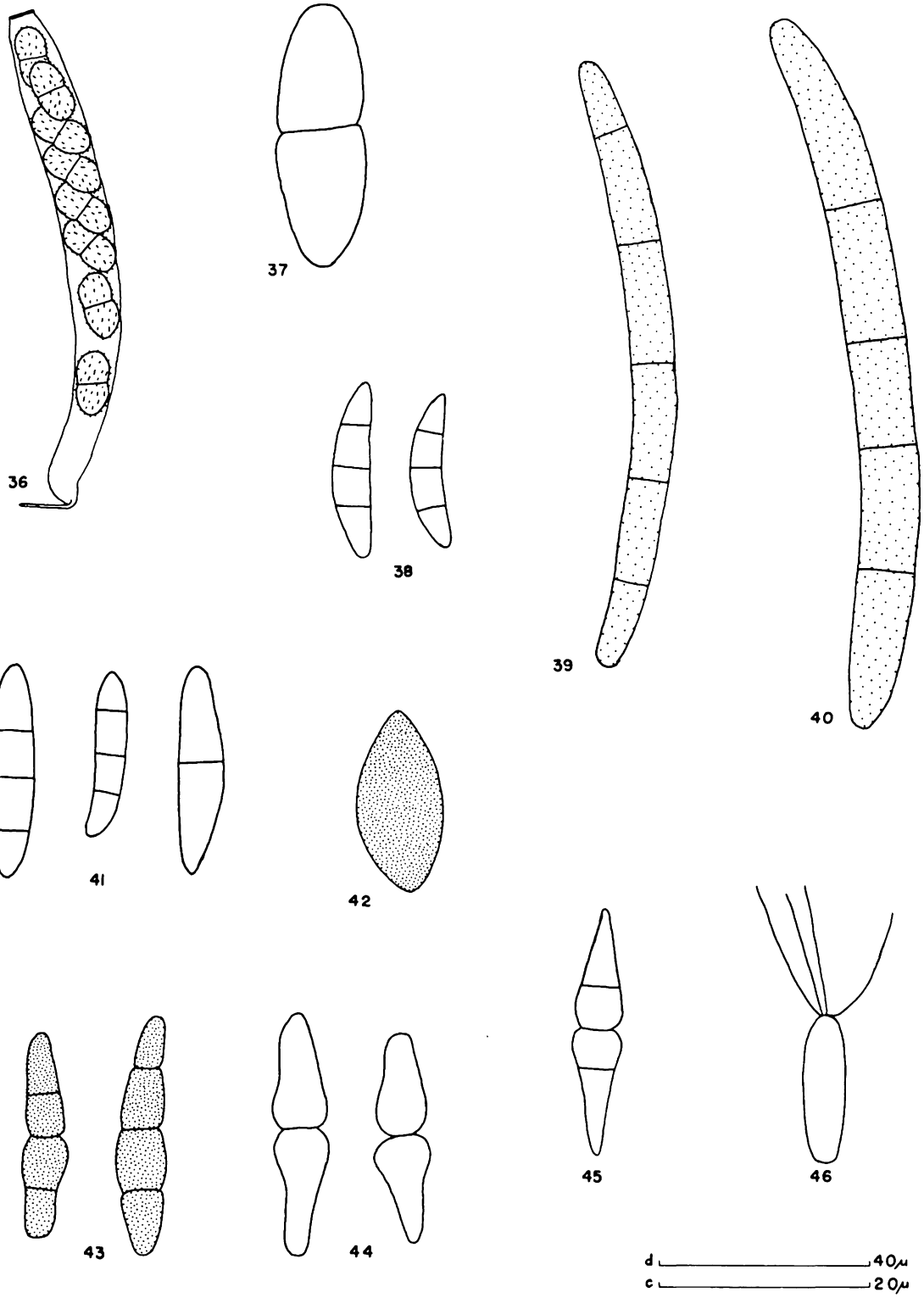
Fig. 42 # 20: ascospore (c)

Fig. 43 # 4: ascospores (c)

Fig. 44 # 1: ascospores (c)

Fig. 45 # 2: ascospore (c)

Fig. 46 # 7: ascospore (c)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ABSTRACT

A survey of the literature reveals little information concerning the aquatic fungi associated with submerged wood debris. During the past fifteen years several mycologists have studied such lignicolous fungi, but their efforts have been confined almost entirely to marine and brackish waters. It was thought that a study of similar organisms from fresh water would make a significant addition to our knowledge of aquatic fungi. This study involves the collection, identification, and description of freshwater lignicolous fungi from the area about Blacksburg, Virginia.

To collect the fungi, sterilized panels of pine and poplar were submerged at six aquatic sites for fifteen days or more. After submergence the wood was incubated in sterile moisture chambers and then examined with a dissecting microscope. Specimens of fungi found on the wood-surface were mounted and studied under high power.

All of the collections are described in this paper, including those that could not be identified. Generic description have been adapted. Descriptions of species have been adapted and modified from the literature when they have seemed adequate, otherwise they are the author's own. Reproductive structures are illustrated. A key to the identified fungi is provided.

The following fungi were identified and described: Dematiaceae - Alternaria sp., Bisporomyces chlamydosporis, Cacumisporium sp., Dictyosporium elegans, Dictyosporium sp., Gonytrichum macrocladum, Humicola sp., Leptographium sp., Monotospora megalospora, Piricauda sp.,

Septonema hormiscium, S. secedens, Sporidesmium caespitulosum, S. anglicum, Sporoschisma saccardoi, Trichocladium opacum; Moniliaceae - Arthrobotrys sp., Clathrosphaerina zalewski, Fusarium solani, Helicomyces roseus, Hobsonia mirabilis, Verticillium sp.; Tuberculariaceae - Bactrodesmium arnaudii; Sphaeropsidales - Aposphaeria agminalis, Asteromella sp., Coniothyrium sp., Stagonospora sp. (1), Stagonospora sp. (2); Actinomycetes - Nocardia sp.; Pyrenomycetes - Nectria sp. Two unidentified Dematiaceae and ten unidentified Pyrenomycetes were also collected and described.

A comparison of the results of this study with the results of other investigations on aquatic fungi indicates the existence of a distinct aquatic mycoflora associated with wood. Aquatic Hyphomycetes have been extensively collected by other workers from submerged leaves and from pond and stream scum. None of the species, not even the genera, of those collections have been found in the present survey. No lignicolous Phycomycetes were found in the present survey, although aquatic Phycomycetes are known to grow on a vast array of substrates.

The fresh-water population of lignicolous fungi may be fairly distinct from that of salt water. A survey of marine fungi reveals only five fungi - Alternaria sp., Dictyosporium elegans, Humicola sp., Trichocladium sp., Coniothyrium sp., Nectria sp. - that can be considered closely related to fungi found in the present study.

This study provides some insight into the ecology of the fresh-water lignicolous fungi, although the study itself has been primarily taxonomic. Perhaps the most important problem now is to determine the actual habitat of these fungi. Research so far indicates only that they grow

on wood and that their spores are carried in the water. Another problem is to investigate the nutrition of these organisms, to determine if they digest lignin and if they are unique in this regard.