Decay in mine timbers. Part II. Basidiomycetes associated with decay of coal mine timbers

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Abstract

In an effort to identify fungi responsible for decay of coal mine timbers, 177 basidiomycetous isolates - 158 of which were identified - were obtained from decaying timbers in 18 mines from 6 major coal mining states. The brown-rot fungus *Coniophora puteana* comprising 83 of these isolates frequently was isolated from both hardwood and softwood hosts. Twenty-seven other fungi were identified from the remaining isolates. Of these, only "Chain-chlamydospore," *Irpex lacteus, Cystostereum pini-canadense, Coriolus versicolor, Stereum gausapatum, S. complicatum, Xylobolus frustulatus,* and "Unknown R" were isolated four or more times. The frequency of fungal isolation by mine locale was recorded.

Identification of the fungi involved in decay of specific wood products can aid in development of techniques for detection of decay in these products (12). Knowledge of the fungi detected can lead to efficient control methods aimed at the causal organisms.

Whereas some work has been done on fungi associated with mine timbers, many of the identifications - particularly in the older work - were based upon examination of fructifications, rather than of cultures removed from the decaying wood. Because many of the important wood decay fungi are rarely found fruiting on infected wood, an erroneous idea of the fungi primarily responsible for decay may be obtained in referring to identities based wholly on fruit bodies.

The work reported here is an attempt to provide, through large numbers of isolations, the identities of decay fungi most often associated with mine timbers, of different tree species, obtained from 18 coal mines throughout the United States (13).

Background

Basidiomycetes previously reported as occurring on mine timbers in the United States were compiled by Cowling (7) and included the following: *Armillariella* (*Armillaria*)[1] *mellea* (Vahl ex Fr.) Karst., *Coprinus* sp., *Coriolus* (*Polyporus*) *versicolor* (L. ex Fr.) Quél., *C.* (*Polyporus*) *hirsutus* (Wulf. ex. Fr.) Quél., *Fomitopsis* (*Fomes*) *pinicola* (Swartz ex Fr.) Karst., *F. rosea* (*Fomes roseus*) (Alb. et Schw. ex Fr.) Karst., *Ganoderma applanatum* (*Fomes applanatus*) (Pers. ex Wallr.) Pat., *Gloeophyllum* (*Lenzites*) sp., *Hericium erinaceum* (*Hydnum erinaceus*) (Bull. ex Fr.) Pers., *Heterobasidion annosum* (*Fomes annosus*) (Fr.) Bref., *Pleurotus ulmarius* (Bull. ex Fr.) Kumm., *Pycnoporellus alboluteus* (Ell. et Ev.) Kotl. et Pouz., and *Serpula lacrimans* (*Merulius lacrymans*) (Wulf. ex Fr.) S. F. Gray. The importance of each of these fungi in the decay of mine timbers was not provided.

[1]Fungal names in parentheses are those cited in the reviewed papers.

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Later, Duncan and Lombard (10) listed the decay fungi associated with decay of wood items examined by the Forest Service. Those associated with mine timbers were *C. versicolor, Phellinus* (*Fomes*) *pini* (Thore ex Fr.) A. Ames, and *S. lacrimans.* The small number of fungal isolations reported from mine timbers precluded any useful determination of relative importance of different fungi in mine timber decay. Hardwood posts in a Pennsylvania coal mine were attacked by *C. versicolor, Stereum complicatum* (*rameale*) (Fr.) Fr., *Stereum gausapatum* (Fr.) Fr., and a common species closely resembling *Coniophora puteana* (*cerebella*) (Schum. ex Fr.) Karst. (19).

Humphrey (15) considered *H. annosum* to be the worst decayer of coniferous timbers in mines. However, as Humphrey's mine isolate from Pennsylvania has been reidentified as *Irpex lacteus* (Fr. ex Fr.) Fr., his opinion was based upon a misidentification. In a Canadian mine, at depths where the temperature was between 67° and 68°F, *S. lacrimans* was plentiful (14). Recently, a new species of *Melanotus, M. hartii* Ammirati, was discovered causing a white rot of spruce timbers in an Ontario gold mine (1). In an abandoned copper mine, rhizomorphs of *A. mellea* were extensively growing on fir and cedar timbers (11).

A number of fungi have been reported associated with mine timbers abroad: *C. puteana, Fistulina hepatica* (Schaeff.) Fr., *Leucogyrophana* (*Merulius*) *pinastri* (Fr.) Ginns et Weresub, *Tyromyces* (*Polyporus*) *balsameus* (Pk.) Murr., *Inonotus* (*Polyporus*) *dryadeus* (Pers. ex Fr.) Murr., *Rigidoporus lineatus* (Pers.) Ryv. *(Polyporus zonalis*), and *Poria placenta (monticola)* (Fr.) Cke. in a mine in N.S.W., Australia (21); *C. puteana (cerebella), Fibroporia* (*Poria*) *vaillantii* (DC. ex Fr.) Parm., *Lentinus lepideus* Fr., *Antrodia* (*Trametes*) *serialis* (Fr.) Donk, *Hirschioporus* (*Polystictus*) *abietinus* (Dicks. ex Fr.) Donk, and *Paxillus panuoides* Fr. in pit mines of the Upper Silesian coal area of Poland (24).

In the Kola Peninsula, U.S.S.R. mines, where local forest materials are used for supports, fungal species prevailing in forests were found. However, in the Armenian S.S.R. mines, where timber is brought from far away, the storage and house fungi, *S. lacrimans, Serpula minor* (Falck) Bond., *F. vaillantii, Coriolellus vaporarius* (Fr.) Dom., *Coriolus versicolor,* and *P. panuoides,* were more abundant. In addition, the house fungi, *Coniophora puteana, Phlebia gigantea* (Fr. ex Fr.) Donk, *Fibroporia destructor* (Fr.) Parm., and *Gloeophyllum saepiarium* (Fr.) Karst. were common to mines in both areas (3). In a study of pine timbers in mines of the Kola Peninsula, 28 basidiomycetes were found, only three of which - *Haematostereum* (*Stereum) sanguinolentum* (Alb. et Schw. ex Fr.) Fr., *C. puteana,* and *P. gigantea* - were collected more than once (2).

In Hungarian mines, *Stereum hirsutum* (Willd. ex Fr.) S.F. Gray, *Leptoporus fodinarum* (Velen.) Pilát, *Flaviporus brownii* (*Leptoporus rufoflavus*) (Humb. ex Steud.) Donk, *Rigidoporus vitreus* (*Physisporinus vitraeus*) (Pers. ex Fr.) Donk, *Lenzites* (*Trametes*) *betulina* (L. ex Fr.) Fr., and *C. (Trametes) versicolor* were among the most common fungi collected (20). The tropical fungus *F. brownii* has also been reported recently from a mine in Czechoslovakia (16).

In a deserted copper mine in Cornwall, U.K., *C. puteana (cerebella), L. lepideus, Sistotrema (Trechispora) brinkmannii* (Bres.) J. Erikss., *Hyphoderma praetermissum* (Karst.) J. Erikss. et Strid (*Gloeocystidium tenue*), *Poria placenta* (*monticola*), *Poria xantha* (Fr.) Cke., and *S. (Merulius) lacrimans* were found on softwood timbers (17). Cartwright and Findlay (5) considered *F. (Poria) vaillantii* to be probably the most common and destructive fungus on coniferous mine timbers in Great Britain, with *C. puteana (cerebella), L. lepideus, P. panuoides* (on wetter timbers), and *H. annosum* (*F. annosus*) also being of frequent occurrence. On hardwood props, *A. mellea* and *C. versicolor* were the most common species found.

Methods

The collection and description of coal mine timbers was described in Part 1 (13). Upon arrival of these timbers at the Laboratory, a piece about 15cm long was removed from one end of each for isolation of associated fungi. Small pieces of affected wood were aseptically transferred to various growth media. Where two types of decay, white and brown rot, were present on one timber, inoculum from both was obtained in an attempt to isolate both types of responsible fungi. The media involved included the following:

a) Difco malt extract plus agar;

b) Taylor's (23); a chemically defined medium containing benomyl, neomycin sulfate, and streptomycin sulfate as selective agents;

c) Difco potato-dextrose agar containing 2-(4-thiazolyl) benzimidazole hydrochloride and chlortetracycline hydrochloride as selective agents. This is the medium described by Tabata et al. (22) except that PDA was substituted for potato-sucrose agar.

Coggins and Jennings' (6) medium for selective isolation of *S. lacrimans* was included initially. However, growth was generally negative on this medium and it was soon dropped from use.

The isolates obtained were first screened to select out basidiomycetes. These were then subjected to standard tests for culture identification as described by Davidson et al. (8, 9). Stock isolates of the Center for Forest Mycology Research (FPL) were used as identification aids. Nonbasidiomycetous isolates were put aside for separate study.

Results and discussion

A total of 177 basidiomycetous isolates were obtained from coal mine timbers. Of this total, 158 have been identified. The latter comprise 28 different species and are listed in Table 1 in descending order of frequency isolated. Most of the species were isolated no more than two times and can, on this basis, be considered to be of minor importance in mine timber decay. A number of these fungi may be considered to be tree decay fungi, not normally found degrading wood products. Where such fungi are involved in mine timbers, it is believed that infected boles, still in a green or semi-green condition, were installed in the mines and the

TABLE 1. - *Frequency of isolation of 28 basidiomycetes from timbers of 18 mines.*

Fungal species	Frequency isolated
Coniophora puteana (Schum. ex Fr.) Karst.	83
"Chain-chlamydospore"	7
Coriolus versicolor (L. ex Fr.) Quél. (two haploid isolates)	7
Cystostereum pini-canadense (Schw.) Parm.	7
Stereum gausapatum (Fr.) Fr.	7
Irpex lacteus (Fr. ex Fr.) Fr.	6
"Unknown R	5
Stereum complicatum (Fr.) Fr.	4
Xylobolus frustulatus (Pers. ex Fr.) Boid.	4
Antrodia serialis (Fr.) Donk	2
Bjerkandera adusta (Willd. ex Fr.) Karst.	2
Cylindrobasidium albulum (Atk. et Burt) J. Erikss. et Hjortst.	2
Ischnoderma resinosum (Schrad. ex Fr.) Karst. (haploid)	2
Schizophyllum commune Fr.	2
Sistotrema sp.	2
Stereum ochraceo-flavum (Schw.) Ell.	2
Stereum hirsutum (Willd. ex Fr.) S.F. Gray	2
Coprinus micaceus (Bull. ex Fr.) Fr.	2
Coniophora arida (Fr.) Karst.	1
Gloeophyllum saepiarium (Wulf. ex Fr.) Karst.	1
Hericium erinaceum (Bull. ex. Fr.) Pers. (haploid)	1
Hypochnicium analogum (Bourd. et Galz.; J. Erikss.	1
Leptosporomyces ovoideus Jülich	1
Phlebia radiata Fr. (haploid)	1
Polyporus compactus Overh.	1
Poria oleracea Davidson et Lombard	1
Stereum ostrea (Blume et Nees ex Fr.) Fr.	1
Tyromyces balsameus (Pk.) Murr.	1

fungi continued to develop in the moist environment. Product fungi, on the other hand, could be expected to invade the timbers either during outside storage or when the timbers were in use in the mine.

The brown-rot fungus, ***C. puteana,*** which was most freqently isolated by us from coal mine timbers, is an important wood-products decayer, particularly in Europe where it is common in damp buildings and mines (5). The prevalence of this fungus in coal mines in the United States also coincides with the findings of Bondartceva and coworkers (2, 3, 4) in the U.S.S.R.

Overall, we found *C. puteana* to dominate the isolations from both hardwood and coniferous mine timbers (Table 2). The "chain-chlamydospore" fungus, a *Sistotrema* species characterized in culture by chains of chlamydospore-like cells that later develop into microscopic sclerotia, was the second most frequently isolated brown-rot fungus. It was isolated seven times, six of which were from hardwood hosts (Table 2). The fungus "Unknown R," which is considered to be a brown-rot fungus on the basis of its negative oxidase reaction, was isolated five times from hardwood hosts. No other brown-rot fungus was isolated more than two times in this study. In fact, a number of the brown-rot fungi - *S. lacrimans* (3, 14), *G. saepiarium* (3), *F. vaillantii* (5), and *L. betulina* (20) - isolated elsewhere in mines and considered to be of some importance in that habitat, were isolated once or not at all in our study.

Only eight basidiomycetous isolates were obtained from southern pine timbers. Unexpectedly, the white-rot fungus, *I. lacteus,* which is usually found on dead hardwoods and only rarely on softwoods (18), was iso-

TABLE 2. - *Basidiomycetes isolated from coal mine timbers - frequency by host species.*

	Hardwood hosts							Coniferous hosts		
Fungus	White oaks	Red oaks	Maples	Hickories	Cherries	Yellow-poplar	Others	Lodgepole pine	Southern pine	Others
Brown rot										
A. serialis	0	0	0	0	0	0	0	2	0	0
C. puteana	8	7	20	3	5	2	9	24	1	4
C. arida	0	0	0	0	0	0	0	0	1	0
G. saepiarium	0	0	0	0	0	0	0	1	0	0
P. oleracea	1	0	0	0	0	0	0	0	0	0
Sistotrema sp.	0	0	0	1	0	0	1	0	0	0
T. balsameus	0	0	1	0	0	0	0	0	0	0
"Chain-chlam."	1	1	0	0	0	0	4	1	0	0
"Unknown R	3	1	0	1	0	0	0	0	0	0
White rot										
B. adusta	0	0	0	0	0	1	1	0	0	0
C. albulum	0	0	0	0	0	1	1	0	0	0
C. pini-canadense	1	0	0	0	0	2	0	4	0	0
C. versicolor	1	2	1	1	1	0	I	0	0	0
C. micaceus	1	1	0	0	0	0	0	0	0	0
H. analogum	0	0	0	1	0	0	0	0	0	0
H. erinaceum	0	0	1	0	0	0	0	0	0	0
I. lacteus	0	0	0	0	0	0	0	0	6	0
I. resinosum	0	0	0	0	0	0	1	0	0	1
L. ovoideus	0	0	1	0	0	0	0	0	0	0
P. compactus	0	1	0	0	0	0	0	0	0	0
P. radiata	0	1	0	0	0	0	0	0	0	0
S. complicatum	1	2	1	0	0	0	0	0	0	0
S. gausapatum	3	2	0	0	0	0	2	0	0	0
S. hirsutum	0	0	0	0	0	0	2	0	0	0
S. ochraceo-flavum	1	1	0	0	0	0	0	0	0	0
S. ostrea	1	0	0	0	0	0	0	0	0	0
S. commune	0	1	0	0	0	0	1	0	0	0
X. frustulatus	2	2	0	0	0	0	0	0	0	0

TABLE 3. - *Basidiomycetes isolated from coal mine timbers — frequency by mine locale.*

Fungus	Location of mine and predominant wood type					
	Pennsylvania (hardwood)	West Virginia (hardwood)	Illinois (hardwood)	Alabama (both)	Utah (softwood)	Colorado (softwood)
Brown rot						
A. serialis	0	0	0	0	2	0
C. puteana	37	14	3	2	24	3
C. arida	0	0	0	1	0	0
G. saepiarium	0	0	0	0	1	0
P. oleracea	1	0	0	0	0	0
Sistotrema sp.	2	0	0	0	0	0
T. balsameus	0	1	0	0	0	0
"Chain-chlam."	1	2	2	1	1	0
"Unknown R	1	4	0	0	0	0
White rot						
B. adusta	1	1	0	0	0	0
C. albulum	0	1	1	0	0	0
C. pini-canadense	0	3	0	0	4	0
C. versicolor	4	2	1	0	0	0
C. micaceus	0	2	0	0	0	0
H. analogum	0	1	0	0	0	0
H. erinaceum	1	0	0	0	0	0
I. lacteus	0	0	0	6	0	0
I. resinosum	0	1	0	0	1	0
L. ovoideus	0	1	0	0	0	0
P. compactus	0	0	1	0	0	0
P. radiata	0	1	0	0	0	0
S. complicatum	1	3	0	0	0	0
S. gausapatum	1	4	2	0	0	0
S. hirsutum	1	0	1	0	0	0
S. ochraceo-flavum	1	1	0	0	0	0
S. ostrea	0	0	0	1	0	0
S. commune	1	0	1	0	0	0
X. frustulatus	1	1	1	1	0	0
Total	54	43	13	12	33	3

lated most often from these timbers (Table 2). *Cystostereum pini-canadense* was the only other white-rot fungus isolated with greater frequency from conifers than from hardwoods (Table 2). Of the remaining white-rot fungi, only *C. versicolor, S. gausapatum, S. complicatum,* and *X. frustulatus* were isolated four or more times from coal mine timbers, in all cases from hardwood hosts (Table 2).

Brown-rot fungi predominated in Pennsylvania, where mostly hardwoods were used, and Utah, where only softwoods were used (Table 3). In West Virginia, with only hardwood timbers, and Alabama, with both hardwood and softwood timbers, equal numbers of brown- and white-rot fungi were isolated, although white-rotted timbers were collected in greater numbers (13). In the Illinois mines, which had only hardwood timbers, white rot was more frequently encountered (13) and white-rot fungi were most often isolated (Table 3).

Summary

As part of a study dealing with decay appraisal in coal mine timbers, the isolation and identification of basidiomycetes associated with such decay was undertaken. The brown-rot fungus, *Coniophora puteana,* overwhelmingly dominated the isolations made from both soft- and hardwood hosts. Other brown-rot fungi, such as *Serpula lacrimans, Gloeophyllum saepiarium, Fibroporia vaillantii,* and *Lenzites betulina,* previously reported elsewhere as important mine timber decayers, were isolated but once or not at all in the present study.

Nineteen different species of white-rot fungi were isolated, although individually none were isolated in large numbers. *Coriolus versicolor, Stereum gausapatum, and Cystostereum pini-canadense* - each isolated seven times - and *Irpex lacteus* - isolated six times - were the most frequently isolated white-rot fungi. The first two fungi were associated solely with hardwood timbers, while *C. pini-canadense* was associated with both hardwoods and softwoods and *I. lacteus* solely with softwoods.

Based on these results *C. puteana* should be included in any future study on detection or control of mine timber decay where it is deemed desirable to work with known fungus cultures. As representatives of the white-rot fungi, *C. versicolor* or *S. gausapatum* could also be included in such studies.

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