Diversity of Lignicolous Basidiomycetes in Coarse Woody Debris

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Abstract

Basidiomycetes are the most conspicuous fungi on wood and are the main decomposers. Lignicolous basidiomycetes include whtte-rotters that remove both lignin and cellulose, and brown-rotters that remove only the cellulose and hemicellulose. The South is a region of diverse lignicolous basidiomycetes because it is the northern limit for many tropical and subtropical taxa and the southern limit for many north temperate taxa. Niches for various taxa are defined by host, substrate, size, and degree of decay. Hence, diversity of these fungi can be enhanced by a mixture of woody angiosperm and gymnosperm debris of different decay and size classes.

Introduction

Southern forests support a species-rich flora of lignicolous fungi. This diversity has its basis in the favorable climatic conditions of the region and the variety of woody plant hosts. The warm temperatures and abundant precipitation are ideal conditions for many species of fungi. Most filamentous fungi that inhabit woody debris are ascomycetes, deuteromycetes, and basidiomycetes. This discussion will be limited to basidiomycetes, which are the most conspicuous fungi on wood and are the major decomposers.

Lignicolous basidiomycetes are divided into two groups based on the type of decay they cause. Fungi that remove both the lignin and cellulose from wood are called white-rotters. The decayed wood is often bleached, with a spongy or stringy texture. Most lignicolous basidiomycetes are associated with a white-rot decay. Fungi that selectively remove the cellulose and hemicellulose, leaving the lignin behind, are referred to as brown-rotters. The woody residues are characteristically dark brown and crumbly, and fall apart in cubes. Only about 6 percent of lignicolous basidiomycetes are known to be associated with brown-rot decay (Gilbertson 1980). There are at least 125 species of brown-rot basidiomycetes, which are classified in four orders: Aphyllophorales (Corticiaceae, Coniophoraceae, Fistulinaceae, Polyporaceae), Agaricales, Tremellales, and Dacrymycetales. A majority of the brown-rot species (70 percent) are members of the Polyporaceae (Gilbertson 1981). About 85 percent of brown-rot fungi are associated with gymnospermous hosts (Gilbertson 1980; Nobles 1958). In some regions, cubical brown-rot residues are the major component in the soils (Harvey and others 1976a; McFee and Stone 1966) and the primary site of ectomycorrhizal root development (Harvey and others 1976b).

The Southern United States hosts the most diverse mycota of lignicolous basidiomycetes in the country. This area is the northern limit for many tropical and subtropical lignicolous basidiomycetes such as *Aleurodiscus mirabilis* and *Gloeodontia discolor*. Similarly, many north temperate species have their most southern distribution in the southeast; *Veluticeps ambigua* and *Phlebia acerina* are examples. Other taxa, such as *Inonotus ludovicianus* and *Resinicium meridionalis* are endemic to the Southern United States. In the last 13 years, a number of new species of lignicolous basidiomycetes have been described from this region (Adaskaveg and Gilbertson 1988; Burdsall and Nakasone 1981, 1983; Burdsall and others 1981; Gilbertson and Blackwell 1984, 1985, 1987, 1988; Larsen and Nakasone 1984; Nakasone 1983, 1984). Nevertheless, the lignicolous mycota of the Southern United States is still poorly known, and many new species are yet to be described.

Host and substrate are important biotic factors that contribute to diversity of fungi on wood. Most species of lignicolous fungi are somewhat host specific. For example, *Aleurodiscus mirabilis* is found on branches of rhododendron, where as *Phlebia hydnoidea* typically occurs on American chestnut and occasionally on oak. Other species are found exclusively or preferentially on gymnospermous or angiospermous hosts. *Auriculariopsis albomellea* and most *Resinicium* species, for example, prefer gymnospermous hosts, whereas *P. albida* and most *Stereum* species occur on woody angiosperms. Other species are omnivorous and have no host preference; *Phanerochaete chrysorhizon* and *Subulicystidium longisporum* are examples of these taxa.

Fungi often display preferences in substrates. Some species colonize only live plants and may be pathogenic or nonpathogenic. Although species such as *Armillaria tabescens* and *Heterobasidion annosum* are aggressive pathogens, many other species are nonpathogenic on living tissue. For example, nonpathogenic fungal endophytes that

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colonize living limbs are also the first ones to decay the dead limbs (Chapela 1989; Chapela and Boddy 1988). Most endophytes are ascomycetes or deuteromycetes. Some basidiomycetes, such as *Dendrothele,* fruit only on bark of living trees. Other species, such as *A. mirabilis* and *Dendrophora versiformis,* fruit primarily on bark of dead branches. Decorticated wood is the preferred. substrate for some taxa; however, most species are found on bark and woody tissue. Species of *Resinicium* fruit on decorticated wood, but *Phlebiella vaga* and *Phlebia chrysocreas,* common and widely distributed species, develop sporocarps on bark and wood.

The size of the substrate is also important. Typically, large fruiting bodies are associated with logs. stumps, and snags. For example, *Laetiporus sulphureus* develops fruiting bodies on logs and stumps, and *Armillaria tabescens* is associated with stumps and roots of trees. Other species are specific to branches and twigs. *Stereum striatum* is frequently found on small-diameter twigs and branches of *Carpinus.*

The degree of decay of the woody substrate can also influence fungal diversity. Some lignicolous fungi are associated only with well-rotted wood. These are often fragile or ephemereal species such as *Trechispora farinacea, Amphinema byssoides* and other mycorrhizal corticioid species also develop fruiting bodies on well-rotted wood. In contrast, *Cryptoporus volvatus* commonly fruits within a year after death of its conifer tree host before being replaced by other lignicolous fungi (Gilbertson and Ryvarden 1986).

Some lignicolous fungi also prey on nematodes that inhabit wood. Because nitrogen is in limited supply in woody substrates, many species use nematodes and microbes as nitrogen sources. These fungi have developed several mechanisms to capture nematodes (Thorn and Barron 1984). Specialized cells called stephanocysts produced in some species of *Hyphoderma* become attached to the nematodes and eventually invade the host (Liou and Tzean 1992). Species of *Hoehnbuehelia* produce adhesive cells to catch their prey whereas *Pleurotus ostreatus* produces a toxin that inactivates nematodes. *Pleurotus ostreatus* and other species of lignicolous fungi also utilize bacteria as a nutrient source (Barren 1988; Blanchette and Shaw 1978).

To examine the diversity of lignicolous fungi in more detail, species associated with sweetgum *(Liquidambar styraciflua* L.) and loblolly pine *(Pinus taeda* L.) will be considered. A list of lignicolous basidiomycetes recorded on these hosts is shown in the appendix. Most records were taken from *Fungi on Plants and Plant Products* (Farr and others 1989); other records are from the Forest Products Laboratory. The list is not exhaustive. At least 73 species of lignicolous basidiomycetes are associated with loblolly pine and 120 species with sweetgum, compared to 228 species reported for ponderosa pine (Gilbertson 1974) and 260 for aspen (Lindsey and Gilbertson 1978). The taxa are distributed in five orders, with most species classified in the order Aphyllophorales (table 1). Within the Aphyllophorales the majority of species are classified into two families: the Corticiaceae, which consist of many white-spored genera that have a primarily resupinate habit, and the Polyporaceae, which include most of the poroid genera. Fifty-two and 80 genera have been reported on loblolly pine and sweetgum, respectively, representing a total of 103 different genera. A few genera are represented by four or more species: *Pleurotus, Hyphoderma, Phanerochaete, Phlebia, Phellinus,* and *Stereum.*

Table l—Distribution of lignicolous basidiomycetes on loblolly pine and sweetgum by order

Order	Loblolly pine	Sweetgum
Agaricales	5	17
Aphyllophorales		
Corticiaceae	27	33
Hymenochaetaceae	4	8
Lachnocladiaceae	2	4
Polyporaceae	25	36
Stereaceae	0	5
All other families	5	10
Auriculariales	1	2
Dacrymycetales	4	2
Tremellales	0	3

Table 2—Lignicolous basidiomycetes common to both sweetgum and loblolly pine

Armillaria tabescens	*Laxitextum bicolor*
Auricularia auricula	*Nigroporus vinosus*
Dacryopinax spathularia	*Phanerochaete burtii*
Diplomitoporus overholtsii	*Phanerochaete chrysorhizon*
Gloeophyllum sepiarium	*Phanerochaete flavido-alba*
Hyphoderma praetermissum	*Phlebiella vaga*
Hyphoderma puberum	*Schizophyllum commune*
Hyphoderma setigerum	*Subulicystidium longisporum*

No representatives of the Stereaceae have been reported on loblolly pine. In North America, *Stereum*, a common and widespread genus, occurs primarily on angiospermous hosts; *Stereum sanguinolentum* is the only species that occurs on conifers, but it has not been recorded on loblolly pine. Similarly, most species in the Hymenochaetaceae and Lachnocladiaceae are associated with angiospermous hosts.

Of the 193 taxa reported on both sweetgum and loblolly pine, only 16 species (9 percent) are common to both hosts (table 2). Most of these taxa are common and widely distributed throughout North America. Five species of brown-rot fungi have been reported on sweetgum compared to 14 species on loblolly pine (table 3). This represents about 4 percent and 19 percent, respectively, of all the fungi reported from these hosts. These values are similar to that found for other gymnospermous and angiospermous hosts (Gilbertson 1980, 1981).

Table 3—Brown-rot decay fungi on loblolly pine and sweetgum

Loblolly pine	Sweetgum
Antrodia radiculosa	*Dacrymyces minor*
Antrodia serialis	*Dacryopinax spathularia*
Antrodia xantha	*Fomitopsis spraguei*
Coniophora olivascens	*Gloeophyllum sepiarium*
Dacrymyces stillatus	*Gloeophyllum trabeum*
Dacryopinax spathularia	
Fomitopsis palustris	
Gloeophyllum carbonarium	
Gloeophyllum sepiarium	
Laetiporus persicinus	
Phaeolus schweinitzii	
Postia caesia	
Postia guttulata	
Wolfiporia cocos	

Table 4-Sibling fungal species on loblolly pine and sweetgum

Loblolly pine	Sweetgum
Dacrymyces stillatus	*Dacrymyces minor*
Inonotus circinatus	*Inonotus ludovicianus*
Ganoderma meredithae	*Ganoderma lucidum*
Junghuhnia luteoalba	*Junghuhnia nitida*
Meruliopsis ambiguus	*Meruliopsis corium*
Peniophora pini subsp. duplex	*Peniophora violaceolivida*
Perenniporia subacida	*Perenniporia tenuis*
Scytinostroma galactinum	*Scytinostroma protrusum*

Several sibling species occur on loblolly pine and sweetgum (table 4). These species are morphologically similar and often share a similar habit, but one taxon occurs primarily or exclusively on angiospermous wood whereas the other prefers gymnospermous wood. For example, fruit bodies of *Scytinostroma galactinum* and *S. protrusum* are morphologically identical but can be distinguished by isozymes and cultural morphology (Nakasone and Micales 1988). In addition, S. *galactinum* occurs exclusively on gymnosperms, whereas *S. protrusum* is known only on woody angiosperms.

Accurate totals of species of lignicolous fungi have become available only recently. Ginns and Lefebvre (1993) included 1,163 species of lignicolous, corticioid basidiomycetes (including the jelly fungi) from Canada and the United States. Gilbertson and Ryvarden (1986-87) described 411 species of polypores from North America. Added to the approximately 620 species of Agaricales (Gilbertson 1980) that occur on wood, the total number of lignicolous basidiomycetes reported from North America is 2,194. Therefore, the 177 unique species on sweetgum and loblolly pine represent 8.1 percent of the total mycota of lignicolous basidiomycetes from North America.

As an example of the potential diversity in the Southern United States, we can examine the fungi reported from different habitats and hosts from this region. Jung (1987) described 130 species of wood-rotting Aphyllophorales from the spruce fir forest of the Southern Appalachians. Only 38 species (29 percent) are also reported on sweetgum and loblolly pine; 92 species (71 percent), representing 25 genera, are not reported. Similarly, Gilbertson and Blackwell (1985, 1987) described 51 taxa of lignicolous fungi on juniper in the Gulf Coast region, of which 41 species do not occur on loblolly pine or sweetgum, or in the spruce fir forest.

These examples can be used to obtain a rough estimate of the number of species of lignicolous basidiomycetes that occur in the Southern United States. A total of 300 different lignicolous species are reported on loblolly pine, sweetgum, and juniper, and from the spruce fir forest region. A conservative estimate for this region is 600 species; an optimistic estimate is 1,000 species. It is important to remember that this entire discussion has focused on fungi that produce fruiting bodies. There are

probably many species living in woody tissue that rarely or never produce fruiting bodies because the environmental conditions are not optimal. Although many of these species can be cultured, they often cannot be identified. Thus, by relying on sporocarps to evaluate fungal diversity, we are sampling just a part of the mycota.

In summary, the diversity of lignicolous basidiomycetes in the southern forests is directly related to the quality and quantity of the coarse woody debris. Diversity of these fungi can be enhanced by a mixture of woody angiosperm and gymnosperm debris of different decay and size classes.

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Appendix

Basidiomycetes that decay loblolly pine and sweetgum[a]

Order	Family	Genera: Loblolly pine	Genera: Sweetgum
Agaricales		*Armillaria tabescens* *Hohenbuehelia pinacearum* *Pholiota spumosa* *Phyllotopsis nidulans* *Tricholomopsis rutilans*	*Armillaria mellea* *Armillaria tabescens* *Coprinus disseminates* *Gymnophilus armillatus* *Gymnophilus praefloccosus* *Lentinellus ursinus* *Lentinus strigosus* *Lentinus tigrinus* *Oudemansiella canarii* *Panellus pusillus* * *Pholiota limonella* *Pleurotus cystidiosus* *Pleurotus dryinus* *Pleurotus levis* *Pleurotus ostreatus* *Simocybe ataomacea* *Volvariella bombycina* *Gloeodontia discolor* *Clavicorona pyxidata*
Aphyllophorales	**Auriscalpiaceae** **Clavariaceae** **Coniophoraceae** **Corticiaceae**	*Coniophora olivascens* * *Amphinema byssoides* * *Chaetoporellus latitans* * *Confertobasidium olivaceo-album* *Grandinia arguta* * *Grandinia barbajovis* * *Grandinia pallidula* * *Hyphoderma pallidum* * *Hyphoderma praetermissum* * *Hyphoderma puberum* * *Hyphoderma sambuci* *Hyphoderma setigerum* *Hyphodontia arguta* * *Hyphodontia barbajovis* * *Hyphodontia pallidula* *Laxitextum bicolor* *Meruliopsis ambiguus* *Meruliopsis taxicola* *Peniophora pini subsp. duplex* *phanerochaete burtii* *Phanerochaete chrysorhiza* * *Phanerochaete flavido-alba*	* *Botryobasidium vagum* *Candelabrochaete langlosii* *Cylindrobasidium laeve* * *Dendrophora versiformis* *Dendrothele microspora* *Dendrothele strumosa* *Gloeocystidiellum porosum* *Gloeocystidiellum turpe* *Gloeoporus dichrous* *Hyphoderma mutatum* * *Hyphoderma praetermissum* * *Hyphoderma puberum* *Hyphoderma rimosum* *Hyphoderma setigerum* * *Meruilopsis corium* * *Peniophora violaceo-livida* *Phanerochaete burtii* *Phanerochaete chrysorhiza* *Phanerochaete crassa* *Phanerochaete flavido-alba* *Phanerochaete velutina*

Basidiomycetes that decay loblolly pine and sweetgum[a] (continued)

Order	Family	Genera: Loblolly pine	Genera: Sweetgum
		* *Phanerochaete gigantea*	*Phlebia chrysocreas*
		Phanerochaete sordida	*Phlebia ludoviciana*
		Phlebiella vaga	* *Phlebia radiata*
		Pseudomerulius curtisii	*Phlebia setulosa*
		* *Resinicium bicolor*	* *Phlebiella vaga*
		* *Resinicium furfuraceum*	* *Pulcherricium caeruleum*
		Resinicium meridionale	* *Schizopora flavipora*
		Scytinostromella fallax	* *Schizopora paradoxa*
		* *Subulicystidium longisporum*	* *Subulicystidium longisporum*
			* *Trechispora farinacea*
			* *Trechispora regularis*
			* *Xenasmatella tulasnelloidea*
	Ganodermataceae	*Ganoderma meredithae*[b]	*Ganoderma lucidum*
	Hericiaceae		*Hericium erinaceus*
			Laxitextum bicolor
	Hydnaceae	*Mycorrhaphium adustum*	*Climacodon pulcherrimus*
			Climacodon septentrionalis
	Hymenochaetaceae	*Hymenochaete pinnatifida*	*Hymenochaete agglutinans*
		Inonotus circinatus	*Inonotus ludovicianus*
		Phellinus pini	* *Inonotus rickii*
		Phellinus viticola	*Phellinus conchatus*
			Phellinus ferruginosus
			Phellinus gilvus
			Phellinus laevigatus
			Phellinus melleoporus
	Lachnocladiaceae	*Dichostereum pallescens*	* *Asterostrona cervicolor*
		Scytinostroma galactinum	* *Dichostereum sordulentum*
			* *Scytinostroma protrusum*
			* *Vararia sphaericospora*
	Polyporaceae	* *Antrodia radiculosa*	*Bjerkandera adusta*
		Antrodia serialis	*Ceriporia xylostromatoides*
		* *Antrodia xantha*	* *Ceriporiopsis pannocincta*
		* *Ceriporia tarda*	*Cerrena unicolor*
		Coriolopsis gallica	*Coriolopsis rigida*
		Cryptoporus volvatus	*Daedaleopsis confragosa*
		Dichomitus squalens	* *Diplomitoporus overholtsii*
		* *Diplomitoporus overholtsii*	*Fomes fasciatus*
		Fomitopsis palustris	*Fomitella supina*
		* *Gloeophyllum carbonarium*	*Fomitopsis spraguei*
		Gloeophyllum sepiarium	*Gloeophyllum sepiarium*
		Heterobasidion annosum	*Gloeophyllum trabeum*
		Junghuhnia luteoalba	* *Heteroporus biennis*
		* *Laetiporus persicinus*	*Hexagonia hydnoides*

Basidiomycetes that decay loblolly pine and sweetgum[a] (continued)

Order	Family	Genera: Loblolly pine	Genera: Sweetgum
		Meripilus sumstinei	*Junghuhnia nitida*
		Nigroporus vinosus	*Lenzites betulina*
		Perenniporia subacida	*Nigroporus vinosus*
		Phaeolus schweinitzii	*Oxyporus latemarginatus*
		Postia caesia	* *Perenniporia compacta*
		Postia guttulata	* *Perenniporia tenuis*
		Skeletocutis amorpha	*Polyporus arcularius*
		Skeletocutis nivea	*Pycnoporus cinnabarinus*
		Trichaptum abietinum	*Pycnoporus sanguineus*
		Tyromyces chinoeus	*Rigidoporus lineatus*
		Wolfiporia cocos	*Rigidoporus ulmarius*
			Tinctoporellus epimiltinus
			Tiametes hirsuta
			Trametes subectypus
			Trametes versicolor
			Trichaptum biforme
			Trichaptum sector
			* *Tyromyces fissilis*
			Tyromyces galactinus
			* *Wrightoporia avellanea*
	Steccherinaceae		*Steccherinum ochraceum*
			* *Steccherinum subrawakense*
	Stereaceae		*Stereum hirsutum*
			Stereum ochraceo-flavum
			Stereum ostrea
			Stereum striatum
			Xylobolus subpileatus
	Schizophyllaceae	*Schizophyllum commune*	*Schizophyllum commune*
	Thelephoraceae	*Tomentella ferruginea*	
Auriculariales		* *Auricularia auricula*	*Auricularia auricula*
			Auricularia cornea
Dacrymycetales		* *Cerinomyces pallidus*	* *Dacrymyces minor*
		Dacrymyces chrysospermus	*Dacryopinax spathularia*
		Dacrymyces stillatus	
		Dacryopinax spathularia	
Tremellales			*Exidia recisa*
			* *Heterochaete shearii*
			Tremella mesenterica

[a]Species listed in Farr and others (1989). Those with an asterisk (*) are from records in Center for Forest Mycology Research. Forest Products Laboratory.
[b]Obtained from Adaskaveg and Gilbertson (1988).

Biodiversity and Coarse Windy Debris in Southern Forests

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CAUTION Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife-if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

McMinn, **James W.; Crossley, D.A., Jr., eds.** 1996. Biodiversity and coarse woody debris in southern forests, proceedings of the workshop on coarse woody debris in southern forests: effects on biodiversity; 1993 October 18-20; Athens, GA. Gen. Tech. Rep. SE-94. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 146 p.

Seventeen papers address the current state of knowledge about the influences of coarse woody debris (CWD) on the biodiversity of various groups of biota. The generation of CWD, its accumulation on forest floors, and its distribution are functions of stand age and management in the South. The effects of CWD on biodversity depend upon harvesting variables, distribution, and dynamics. Research priorities are identified for future studies that should provide a basis for the conservation of biodiversity when interacting with appropriate management techniques.