Common Wood Decay Fungi Found in the Caribbean Basin

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There are hundreds of wood-decay fungi in the Caribbean Basin, but relatively few of these are likely to grow on man-made structures built of wood or wood-composites. The wood-decay fungi of greatest concern are those that cause brown-rot, and especially brown-rot fungi that are resistant to copper-based wood preservatives. Some fungi that grow in the Caribbean and produce white-rot are able to grow in very hot and sometimes dry or salty environments; consequently, these fungi are sometimes observed on older man-made structures such as decks and posts. While the origin and history of the wood used in structures that are decayed by white-rot fungi is usually unknown, it is likely that many were built with some type of treated wood and that the treatment had lost its effectiveness over time. No copper-tolerant white-rot fungi have appeared in wood preservative trials conducted in challenging tropical environments. Another characteristic of concern in some brown- and white-rot fungi is the ability to form rhizomorphs or cords (root-like structures) because fungi can transport nutrients and water between food bases through these structures, and fungi sometimes grow across surfaces of preserved wood and colonize unprotected wood that is joined to it.

CALCIUM OXALATE AND COPPER TOLERANCE

Clausen et al. (2000) and Green & Clausen (2005) showed a correlation between calcium oxalate production and copper tolerance in seven brown-rot fungi. However, white-rot fungi also produce calcium oxalate but are apparently not copper tolerant. Jarosz-Wilkolazka and Gadd (2003) found no significant differences between the growth of brown- or white-rot fungi on controls (metal-free) and on the 0.5% $CaCO_3$, $CO_3(PO4)_2$ or $Zn_3(PO4)_2$-amended plates. Schilling (2006) suggested that the correlation between oxalate production and copper tolerance may be incidental since Schilling and Jellison (2006) showed metal accumulation without enhanced oxalate secretion in wood degraded by brown rot fungi. High-throughput transcriptome sequencing of *Fibroporia radiculosa* by Tang et al. (2013) suggest there are multiple genes that were up-regulated in the presence of copper, including genes for calcium oxalate metabolism.

BROWN-ROT FUNGI

The most common brown-rot fungi in the Caribbean Basin, as well as the white-rot fungi that are most likely to occur in the hot, dry environments associated with houses in this tropical to subtropical region are presented in Table 1 together with their geographic distribution and important traits. Of the brown-rot fungi, *F. radiculosa* (Figs. 1-2) is of greatest potential concern because it is widespread, copper tolerant, grows on conifer wood that is often used in construction, and it has rhizomorphs. *Fomitopsis palustris* is also of concern as it is widespread on all types of wood and is copper tolerant but lacks rhizomorphs. Two species that are primarily on conifer wood are *Fomitopsis cupreorosea* (Fig. 3), which often has sinuous to labyrinthine pores and is widely distributed in the Neotropics; and *Fomitopsis cajanderi*, which has round pores and occurs in North America and extends into conifer zones of Central America and the Caribbean (Table 1).

WHITE-ROT FUNGI – SOME LIKE IT HOT

Castillo Cabello & Demoulin (1994) showed wood was hotter and drier in areas lacking in vegetation cover, and that certain wood-decay fungi were present in such areas, such as *Pycnoporus sanguineus* (Fig. 4), *Daldinia eschscholtzii* (Fig. 5) and *Schizophyllum commune* (Fig. 6). Man-made structures in the tropics are usually built in open areas where portions receive direct solar radiation. Wood decks and unshaded wood can therefore reach high temperatures, and it can also be dried by insolation. Sea salt adds to osmotic stress in coastal areas. Several tropical fungi are known to tolerate or thrive under these conditions. Castillo Cabello (as Castillo) & Demoulin (1997) showed that *P. sanguineus* (Fig. 4) had a higher temperature tolerance range than *S. commune* (Fig. 6). Madhosingh (1962) grew *P. sanguineus* at its optimal growth temperature of 35° C, harvested asexual spores, exposed the spores to 75° C for 30 to 150 minutes, and found the spores survived well, germinated and grew at 35° C. Madhosingh (1962) also found the *P. sanguineus* grew only slightly less rapidly at 37.2° C than at 35.5° C (99 vs 96° F), but about 20% slower at 40° C (104° F). Castillo Cabello & Demoulin (1994) found that *S. commune* tolerated temperatures up to 50° C and more than 70 g NaCl l^{-1}. While Castillo Cabello & Demoulin (1994) did not find marked salt tolerance in the *P. sanguineus* strains they tested, Dantán-González et al. (2008) found a strain in coastal Mexico that grew best at 37° C and grew well at a salt concentration similar to that of sea water (500 mM, ca. 35 g NaCl l^{-1}).

CONCLUDING REMARKS

Based on previous research, some wood-decay fungi in the Caribbean Basin can grow under hot, dry and even salty conditions that are frequently associated with man-made structures. A few fungal species can decay what are considered resistant tropical hardwoods. Some brown-rot fungi tolerate copper may also tolerate new micronized formulations of copper and zinc wood protectants based on observations by a commercial wood treatment company in Puerto Rico. We need more fungal identifications of treated wood that is in-service together with data on the type of wood preservative that was used, the length the wood had been in-service and any factors contributing to its failure.

Figure 1. *Fibroporia radiculosa* on untreated pine lumber in Belize (Photo by D.J. Lodge).

Figure 2. *Fibroporia radiculosa*, closeup of laberynthine pores in Fig. 1 (Photo by D.J. Lodge).

Figure 3. *Fomitopsis cupreorosea* is widespread on conifers in the Neotropics (Photo by N. Legon).

Figure 4. *Pycnoporus sanguineus*, which prefers hot, dry conditions throughout the Neotropics (Photo by D.J. Lodge).

Figure 5. *Daldinia eschscholzii* is a Neotropical ascomycete that grows in hot, dry conditions (Photo by D.J. Lodge).

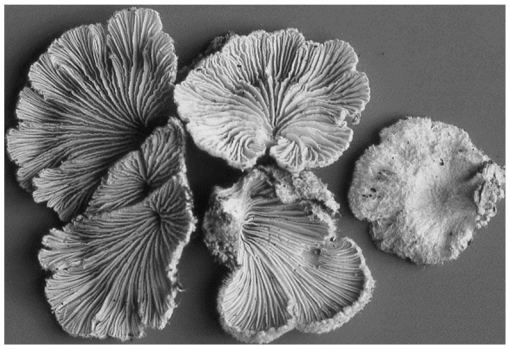

Figure 6. *Schizophyllum commune* is a Pantropical species that prefers hot, dry conditions (Photo by D.J. Lodge).

Table 1. Common wood-decay fungi in the Caribbean Basin and their characteristics.

Fungi causing white-rot	Distribution	Observations
Antrodiella hydrophila	Pantropical	very common
Aurificaria luteo-umbrina	Neotropical, USA Gulf Coast	on hardwoods; *Inonotus*-like
Beenakia informis	Neotropical	pathogen of mahogany; has soft teeth
Bjerkandera adusta	Widespread	on hardwoods, rarely on conifer; highest number of gene copies & high diversity of peroxidases
Hexagonia hydnoides	Pantropical, US Gulf Coast	likes hot, dry areas; hairy, brown
Hydnophlebia chrysorhiza	Primarily Neotropical but occurs in continental USA	has rhizomorphs; tolerates dry areas; uses woody debris
Lentinus crinitis	Widespread in the Americas	tolerates hot, dry areas, white gills
Lentinus berteroi	Neotropical	tolerates hot, dry areas, yellow gills
Phanerochaete flava	Neotropical	has rhizomorphs; moist areas; uses woody debris; yellow overall
Phylloporia chrysita	Pantropical	common; brown hairy wood ear
Podoscypha aculeata	Neotropical, rare in SE USA	hardwoods including teak
'Polyporus' brittonii	Neotropical	huge, soft, resembles *Laetiporus persicinus*; prefers moist to wet areas
Pycnoporus sanguineus	Neotropical	prefers hot, dry areas; has copper radical oxidases; orange overall
Resinicium spp.	Neotropical	has rhizomorphs, Neotropical spp. not same as in N. America
Schizophyllum commune	Ubiquitous	prefers hot, dry areas
Trametes elegans	Widely distributed in SE USA and Neotropics	large white wood ears, larger & paler than *T. versicolor*
Xylariaceae: *Xylaria, Daldinia, Hypoxylon & Kretzschmaria/Ustulina*	Widely distributed but more diverse & abundant in the tropics	all environments - *Daldinia* in hot, dry areas; some degrade resistant tropical hardwoods
Fungi causing brown-rot		
Amylosporus campbellii	Pantropical & Southern USA	on buried wood, tolerates dry areas; light weight, white, stains yellow; odor of gym shoes
Daedalea neotropica	Belize, probably Mexico	on oak; labyrinth-like pores are white, stain purple vs. unstained *D. confagosa*
Fibroporia radiculosa	USA, Caribbean Basin, China	has rhizomorphs; on conifer; copper tolerant; orange labarynthine pores
Fomitopsis: cajanderi, rosea & cupreorosea	Widespread in conifer forests including Caribbean Basin	on conifers, some hardwoods; conks brown to black, pores often rose tinted
Fomitopsis feei	Pantropical & Florida	on hardwoods; conks reddish brown
Fomitopsis nivosa	Neotropical to Florida	on hardwoods, grows on posts; pores white to grayish brown
Fomitopsis palustris	SE USA, Caribbean Basin	all woods; copper tolerant
Gloeophyllum trabeum	Widespread in conifer forest; coastal forests in Bahamas	mostly on conifers; *Casuarina equisetifolia* (Fagales)
Laetiporus caribensis	Widespread in Caribbean	only in wet forest; orange, soft

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