Potential Woodpecker Nest Trees through Artificial Inoculation of Heart Rots[1]

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Abstract.--We suggest that the fungus *Spongipellis pachyodon* might be used to artificially create suitable hardwood nest trees for woodpeckers in both young and older trees and when supplies of potential nest trees are limited. Sizes of trees suitable for inoculation, inoculation heights, and densities of snags are suggested for six species of woodpeckers.

INTRODUCTION

The use of snags by North American woodpeckers for both nesting and foraging is well documented (Balda 1975, Scott et al. 1977, Conner 1978, Evans and Conner 1979, Dickson et al. 1983). While a wide variety of sizes and conditions of snags may be suitable for woodpecker foraging sites, only certain conditions of hardwood snags are suitable for nesting. The heartwood of hardwood snags in particular must be softened by fungal decay before woodpeckers can excavate either nest or roost cavities (Conner et al. 1976). While decayed heartwood in pine (*Pinus* spp.) snags may facilitate cavity excavation, pileated (*Dryocopus pileatus*) and red-headed (*Melanerpes erythrocephalus*) woodpeckers can excavate cavities in undecayed pine snags (Conner, unpubl. data).

The increasing demands for timber products in general and firewood in particular (USDA 1982) may further decrease the availability of hardwoods that are suitable for cavity excavation. We report here a successful technique to artifically inoculate two species of heartwood decaying fungi into oaks (*Quercus* spp.). Such a technique would be valuable in forests where it is desirable to create suitably decayed hardwoods for primary cavity nesters at younger tree ages or in greater abundance than would normally occur.

METHODS

Local live cultures of *Spongipellis pachyodon* (Pers.) Kotl. and Pouz. and *Laetiporus sulphureus* (Bull. ex Fr.) Bond. and Sing. were obtained from decaying hardwood trees during the winter of 1979 on the Stephen F. Austin Experimental Forest, Nacogdoches Co., TX. Chips of wood were aseptically cut from pieces of the decaying hardwoods and placed on malt agar. Both cultures subsequently grown from these inoculations were identified by micro- and macroscopic characteristics and growth patterns. Identifications were verified by Frances Lombard at the Forest Products Laboratory in Madison, WI. *Spongipellis pachyodon* was selected as an inoculum because of its demonstrated association with hardwood cavity trees of woodpeckers in Virginia (Conner et al. 1976). *Laetiporus sulphureus* was selected because it was an indigenous hardwood heart rot that we had in culture.

Hollow oak dowels (5 cm long, 1.1 cm dia. with a 0.4 cm hole from end to end) were autoclaved (132°C for 40 min) in a malt extract broth solution (2.5 g malt extract per 100 ml distilled water). An oak-sawdust agar medium (15 g oak sawdust, 11 g malt agar, 2.5 g wheat bran, 1.25 g corn meal and 70 ml of distilled water per pint jar) was mixed, dispensed in pint jars and autoclaved (122°C for 50 min), and then placed on a slanted rack so the agar would harden at an angle of about 60 degrees. Pint jars were inoculated with either *Spongipellis pachyodon* or *Laetiporus sulphureus* after which four of the sterile hollow dowels were placed on top of the slanting growth medium. After 2 to 3 months' growth the hollow dowels were sufficiently infected with fungi for inoculation into oak trees. This technique modifies those used by Silverborg (1959) and Toole (1965, 1966) to inoculate hardwoods with different species of fungi.

Twenty oak trees (both *Quercus falcata* and *Q. nigra*; DBH: mean = 21.9 $\pm$ standard deviation = 5.2

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cm; height: 19.7 ± 3.6 m; age: 44 ± 5.9 y) were selected in a forested area on the Stephen F. Austin Experimental Forest, Nacogdoches Co., East Texas. Oaks with obvious signs of decay or injury were automatically excluded from selection. On 11 March 1980, after sterilizing drill bits and drill locations on trees with 70% ethanol, we drilled a 1.5 cm dia. hole 13 - 15 cm deep on the north side of each tree 2 m above the ground with an electric drill. We selected the north side of the trees because it would offer the dampest micro-environment. The holes were drilled slightly upward at an angle of 10° above the horizontal to prevent the entrance of rain water and possible contamination into the holes.

Several *Spongipellis pachyodon* infected dowels were inserted into each hole and stacked tightly against each other in 10 of the drilled oaks. The last dowel inserted into each tree was left protruding from the drill hole to help prevent the tree from sealing the hole. Toole (1967) reported that success of fungal inoculations in hardwoods was much higher if the inoculation hole was kept open. We repeated the same procedure on the other 10 oak trees using *Laetiporus sulphureus* infected oak dowels. We did not attempt to inoculate old knots or limb breaks because of a high probability of being contaminated by other fungi.

Five randomly selected oaks from each group that had been inoculated with *S. pachyodon* and *L. sulphureus* were harvested 27 January 1981. The harvest procedure was repeated again on 20 January 1982. Harvested trees were horizontally and vertically sectioned to determine existence and extent of the fungal infections. Small chips of wood from areas that appeared to be infected were aseptically removed and cultured on malt agar to determine if the fungus subsequently grown was the same species that was originally inoculated into the tree.

Use of control trees was deemed unnecessary because sections made of the experimental trees with a chain saw readily demonstrated if fungi had been introduced by our inoculation or were present prior to treatment.

RESULTS

Spongipellis pachyodon was successfully inoculated into and recultured from 80% (8 of 10) of the experimental trees (table 1). While all ten of the *Spongipellis* inoculated trees visibly showed signs of heartwood decaying fungi (discolored and softened wood present in cross sections), we detected no growth of any fungi on reculture attempts for two trees. We strongly suspect that the fungus present in these two trees was *S. pachyodon*. There was no visual evidence in the cross sections of these ten experimental trees indicating the presence of any fungal infections prior to our inoculation.

Laetiporus sulphureus was also successfully inoculated into and recultured from 80% (8 of 10) of the experimental trees (table 1). However, in one of these eight trees a different species of fungus (*Phellinus gilvus* (Schw.) Pat.) was also detected when trying to reculture *L. sulphureus*. The two remaining experimental trees were also infected with fungi. One of these trees appeared to have been infected with *Phellinus gilvus* prior to our inoculation. *Phellinus gilvus* was cultured from heartwood tissue during reculturing attempts. The last of the ten trees had a fungus that did not appear to be *Laetiporus sulphureus* and, unfortunately, we were unable to successfully culture

Table 1.--Growth of heartwood decaying fungi inoculated into oaks (*Quercus falcata* and *Q. niger*) in East Texas.

	Species of Fungi	
	Spongipellis pachyodon n = 10	*Laetiporus sulphureus* n = 10
Success of reisolation	80%	80%
Average 2 year growth above inoculation	31.8 ± 10.1 cm[1]	18.4 ± 5.8 cm
Average 2 year growth below inoculation	25.4 ± 11.3 cm	11.2 ± 1.6 cm
Average annual vertical growth	28.6 cm	14.8 cm
Average annual horizontal growth	5.2 x 2.7 cm	2.6 x 1.4 cm
Other fungi detected in reculture	None	*Phellinus gilvus* in 2 trees

[1]Mean ± standard deviation.

the fungus. We suspect that this unidentified fungus may have been introduced when we originally drilled the tree.

Spongipellis pachyodon grew vertically within the experimental trees at approximately twice the rate of *Laetiporus sulphureus* (table 1). *S. pachyodon* spread at an average vertical rate of 28.6 cm per year while *L. sulphureus* only spread 14.8 cm vertically per year. In three of the five *Spongipellis* inoculated trees that were harvested after 2 years growth white hyphal tissue could be seen growing out of the drill hole around the protruding dowel, almost as if the fungus was beginning to form an external conk or sporophore.

The horizontal growth of *S. pachyodon* averaged 5.2 by 2.7 cm/y (an elliptical area, table 1). This was also approximately twice the dimensions of horizontal growth demonstrated by *L. sulphureus* (2.6 by 1.4 cm/y). The elliptical horizontal growth pattern was caused by the linear nature of the inoculation dowels in the tree. The long axis of the ellipse was parallel to the inoculation dowels.

DISCUSSION AND CONCLUSIONS

The technique used to inoculate heart rots into oaks was quite successful. Although *Spongipellis pachyodon* was recultured from only eight of the ten experimental trees, we believe our actual success was 100%. Our actual success with *Laetiporus sulphureus* was less than that with *S. pachyodon*. This, combined with the greater growth rate of *S. pachyodon*, strongly suggests that *S. pachyodon* would be the preferred fungus to use when inoculating trees for woodpeckers.

In the present study we selected only oak trees to test the success of fungal inoculation. *Spongipellis pachyodon*, however, infects many other species of hardwoods. Conner et al. (1976) detected the fungus in *Quercus alba, Q. rubra, Q. prinus, Q. coccinea* as well as *Acer saccharum* and *Carya tomentosa*. Also, an association between hardwood woodpecker nest trees and *S. pachyodon* has already been demonstrated; ten of the 12 hardwood nest trees that Conner et al. (1976) studied intensively were infected with *S. pachyodon* as the primary decay fungus.

Spongipellis pachyodon grew within the heartwood of the oaks much faster in vertical directions than horizontally. This is caused in part by compartmentalization of wood tissue (Shigo and Marx 1977). Because *Spongipellis pachyodon* spreads slower horizontally than vertically, enough time must elapse for decay to spread to sufficient diameters to house woodpecker cavities. Trees would have to be inoculated at least 6 years prior to intended use for pileated woodpeckers. Six years might permit the decay column to expand to approximately 31 x 16 cm in diameter, a minimum size for pileated cavities (table 2). It is necessary for the decay column to grow to this sufficient diameter because pileated woodpeckers that are excavating cavities in oaks and most other hardwoods usually stop when they encounter undecayed wood at the bottom and on the sides of nest cavities (Conner et al. 1976).

The time required for sufficient growth of decay from inoculation until potential use by other woodpecker species will be shorter than that for pileateds (table 2). It is also important to note that the sapwood in hardwoods must also be decayed before a snag will be suitable as a nest site for downy woodpeckers and northern flickers because these two species typically cannot excavate through undecayed sapwood (Conner et al. 1976).

When artificial inoculation of hardwood trees is feasible we suggest that *Spongipellis pachyodon* be used as the inoculum as described in our methods section. However, trees should be inoculated at heights close to average nest cavity heights for individual woodpecker species and in

Table 2.--Woodpecker cavity and nest tree characteristics.

Species	Average[1] cavity depth	Average[1] cavity diameter	Time for decay	Average nest height	Optimum D.B.H. ranges of nest trees
	(cm)	*(cm)*	*(years)*	*(m)*	*(cm)*
Downy woodpecker *Picoides pubescens*	18	9	3	4.8	15-25
Hairy woodpecker *P. villosus*	35	11	4	8.8	25-35
Pileated woodpecker *Dryocopus pileatus*	48	20	6	13.6	45-65
Northern flicker *Colaptes auratus*	28	14	5	8.5	30-44
Red-bellied woodpecker *Melanerpes carolinus*	30	10	4	7.6	36-53
Red-headed woodpecker *M. erythrocephalus*	30	10	4	7.0	40-60

[1] Conner, unpubl. data--nest cavities from both Virginia and Texas.

trees of the appropriate DBH (table 2, Conner et al. 1975, Jackson 1976). If inoculations are made lower in trees than the average nest height, more time would elapse before the fungus would grow to sufficient dimensions at heights favorable to woodpeckers; low nests would probably have increased predation pressure (Dennis 1969, Kilham 1971, DeWeese and Pillsmore 1972). Most woodpeckers would be able to detect the presence and location of heart rots in potential nest trees by percussing the tree and possibly sensing a "special" resonance that indicates a suitable site for excavation (Conner et al. 1976, Conner, pers. obs.).

Numbers of snags (dead or mostly dead trees) needed as cavity sites by woodpeckers to support varying percentages of population maximums (table 3, revised from Evans and Conner 1979) are important if a forest manager decides to create additional potential nest sites by artificial inoculation. The numbers of snags indicated in table 3 include snags for one cavity nest and three roost sites. It is important to consider roost cavity numbers because individual woodpeckers of many species use several during the course of a year, a behavior that may reduce the probability of predation. Our estimates on the number of roost sites preferred by woodpeckers is probably low. Also included in the number of snags needed is a reserve of 9 snags for each cavity required by a pair of woodpeckers during a year. This includes a margin for snags that are unusable for nesting or roosting, a reserve of snags for replacements, and a supply for secondary users (Bull and Meslow 1977, Evans and Conner 1979). Because competition for cavities often occurs, the needs of secondary cavity nesters must be considered. While some of the reserve of snags will be used as foraging substrate, the numbers of snags recommended for cavity requirements will in no way meet the complete foraging needs of the woodpecker species. Until additional data indicate a revision is needed, we suggest that our estimates are conservative. Quantitative data are needed to show what percentage of standing snags are actually suitable for cavity excavation. The numbers of snags we have suggested can be used as a general guideline for forest resource managers wishing to augment available cavity habitat for both primary and secondary cavity nesters.

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Table 3.--Numbers of snags required to provide cavities to support varying percentages of woodpecker population maximums. (Revised from Evans and Conner 1979 for southern forests)

Species	Snags needed per 4.0 ha for cavities to maintain listed percentages of population maximums				
	Excellent	Good		Fair	Poor
	100	80	60	40	20
	(number)				
Downy woodpecker *Picoides pubescens*	40	32	24	16	8
Hairy woodpecker *P. villosus*	20	16	12	8	4
Pileated woodpecker *Dryocopus pileatus*	5	4	3	2	1
Northern flicker *Colaptes auratus*	5	4	3	2	1
Red-bellied woodpecker *Melanerpes carolinus*	27	22	16	11	6
Red-headed woodpecker *M. erythrocephalus*	20	16	12	8	4

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