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Evaluating the natural durability of native and tropical wood species against *Reticulitermes flavipes*

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Abstract

Environmental pressures to eliminate arsenate from wood preservatives has resulted in voluntary removal of CCA for residential applications in the United States. A new generation of copper organic preservatives has been formulated to replace CCA for decking and in-ground applications but there is no guarantee that these preservatives represent a permanent solution to all related problems. Therefore, it is still necessary to evaluate alternative treatments, as well as naturally durable wood species, in order to be prepared for future changes in the field. In this study, six hardwoods and six softwoods have been evaluated for their ability to resist termite damage by *Reticulitermes flavipes* in a 4-week laboratory no-choice test. In addition, moderately resistant Douglas-fir and southern pine wood blocks were evaluated after treatment with copper borate, copper naphthanate, and N,N-naphthaloylhydroxylamine (NHA). Erisma, juniper, ipe and white-cedar were shown to be highly resistant. NHA protected Douglas-fir and southern pine as effectively as copper borate or copper naphthanate. These results suggest that some naturally durable wood species, both tropical and native, can inhibit *R. flavipes* as effectively as preservative treatment.

Keywords: NHA, copper borate, termite damage, specific gravity, preservative treatment, natural resistance, density

Introduction

Many types of wood have their own natural defenses against insects and other pest species. This is especially true in tropical environments because there is no frost season to help suppress pest populations. Plants and trees have evolved to produce their own line of chemical defenses (i.e. extractives) to keep invaders out. One goal of the wood preservation industry should be to exploit the natural defense mechanisms of durable wood species or simply use the naturally resistant wood itself. By using a compound already found in nature, the environmental impact would be minimal, yet still toxic to the insects.

One objective of this study was to supply background information on the natural resistance of different types of native and tropical woods to termite attack, in comparison to their specific gravity or density. Natural resistance of wood to termite attack seems to be correlated with wood species that have a higher specific gravity. A second objective was to compare treated domestic wood species with untreated domestic wood species.

A similar termite study done by Esenther (1977) serves as a reference for comparison not only between specific species, but also between tropical and non-tropical species as a group. Our data supports Esenther's findings or results that tropical wood species had less overall weight loss to *R. flavipes* than those native wood species found in the United States.

Sections of Alaska yellow cedar were used from different sources in order to test the effects of wood aging on termite resistance. Blocks from one group were under five years old, and the other group had blocks over twenty years old. Our hypothesis was based on the study done by Rudman (1966), which proposed that along with the ageing of the tree, the extractives aged as well. The natural resistance of Alaska Yellow Cedar wood is mostly due to the oil it produces. The oil, which is a known biocide, creates a distinct aroma in heartwood. The presumption is that as the tree gets older the oil would dry up or evaporate, making it more susceptible to attack. DeGroot and Woodward (2000) tested the natural decay resistance of heartwood from both living and dead Alaska yellow cedar trees and found that the heartwood of living trees and those that have been dead less than 80 years may potentially be used in above ground products. Our third objective was to evaluate whether aging in Alaska yellow cedar effects termite resistance.

Materials and Methods

No-Choice Test:

Glass bottles [55 x 55 x 135mm; Owens-Brockway; Owens, OH] were filled with approximately 120 grams of soil and 15 mL of distilled water and then autoclaved for 45 minutes. Soil bottles are used to better replicate the environment in which the termites are found and to deter death by starvation (Green III et al., 1997). *Reticulitermes flavipes* (Kollar) were collected from Janesville, Wisconsin during the months of June, July, and August of 2003. After being removed from the cardboard traps, one gram (~ 275 termites) was added to each of the soil bottles after they had cooled.

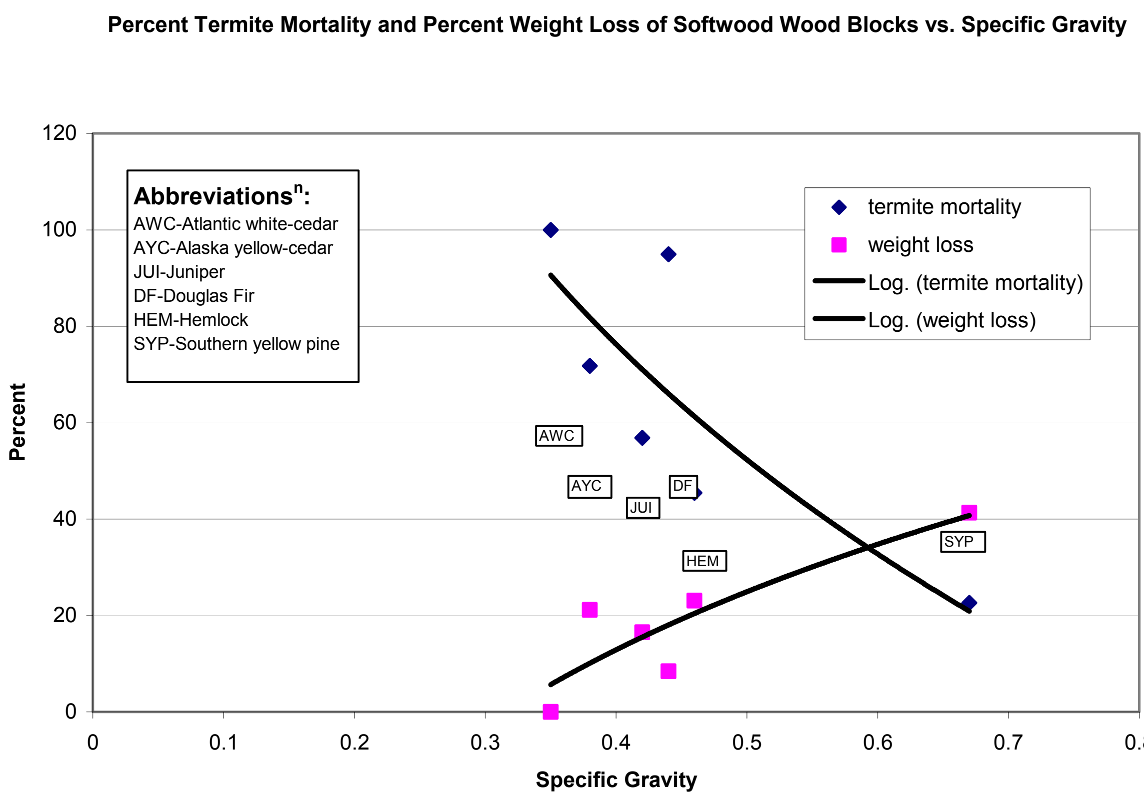
Wood specimens (3 x 27 x 40mm) were conditioned at 27^{o} C and 95% relative humidity overnight, and then they were weighed before they were added to the termite bottles. This way weight loss could be determined based on moisture equilibrium. A total of twelve different species of trees were used, including: Southern Yellow Pine (*Pinus sp.*), Douglas-Fir (*Pseudotsuga menziesii*), Poulsenia (*Poulsenia armata*), Balsa (*Ochroma pyramidale*), Hemlock (*Tsuga sp.*), Ceiba (*Ceiba pentandra*), Alaska Yellow-Cedar (*Chamaecyparis nootkatensis*), Atlantic White-Cedar heartwood (*Chamaecyparis thyoides*), Qualea (*Qualea sp.*), Juniper (*Juniperus sp.*), Erisma (*Erisma sp.*), and Ipe (*Tabebuia sp.*) (Table 1)(Flynn and Holder, 2001). Alaska yellow cedar blocks were classified as either class I , live trees, or class III, trees that have been dead for over 20 years.

Eighteen blocks of Southern yellow pine were vacuum treated with three different chemicals; six were treated with 0.1% CuNaph (copper naphthanate), six were treated with 0.1% CuBor (copper borate), and six were treated with 0.1% NHA (N'N-naphthaloylhydroxamine)(Green III 1997). Fifteen blocks of Douglas-fir were also vacuum treated in the same manner as the Southern yellow pine blocks, but there were only five blocks in each group. These blocks were then dried and conditioned overnight before being added to the termite bottles. The bottles were held in the incubator at 27^{o} C and 95% relative humidity for 28 days, and general observations were noted. If all termites appeared dead, the bottle was taken out and the number of days until 100% mortality was recorded. At the end of the four-week period the blocks were removed and dried overnight. The blocks were then conditioned (27C/95RH) once again for about 24 hours. Weight loss of these blocks was determined after the blocks' moisture level remained consistent. The remaining live termites were weighed and recorded for each of the bottles.

Results and Discussion

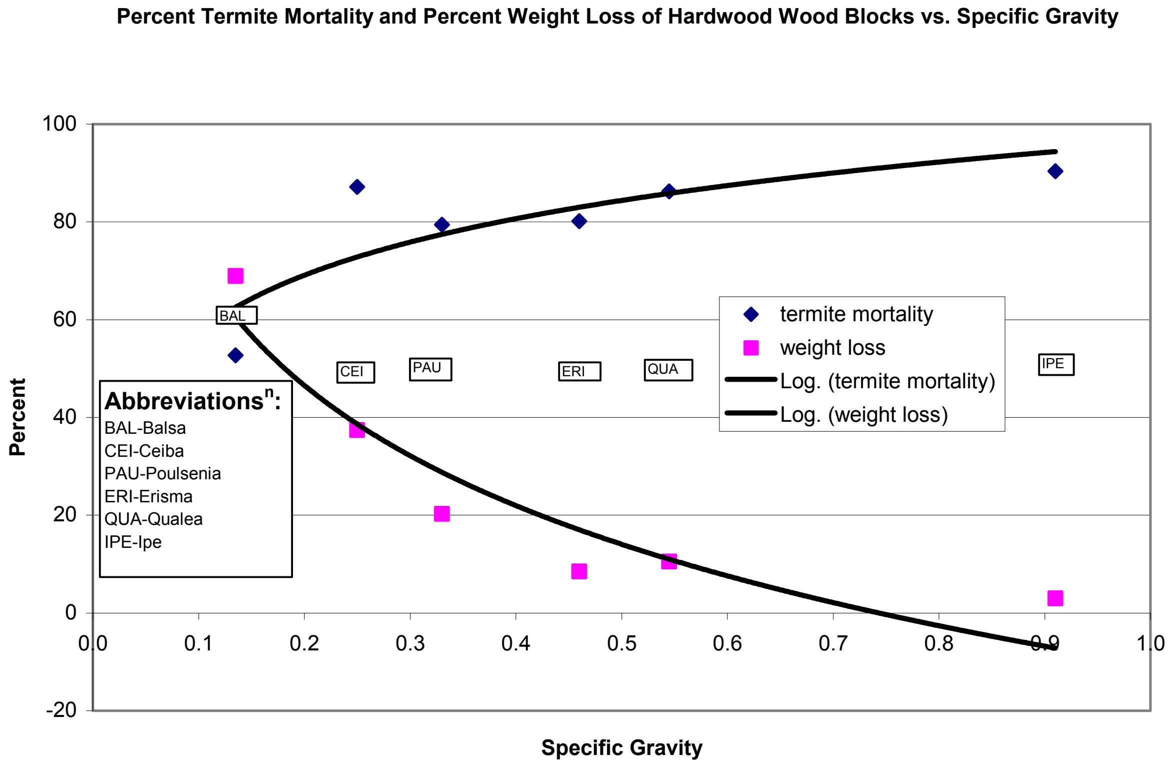
The results of the termite resistance tests are shown in Table 1. Untreated Southern Yellow Pine blocks suffered the highest weight loss (41%). Ipe, a tropical timber found widely dispersed throughout South and Central America, exhibited the lowest amount of termite damage (Flynn and Holder, 2001) along with Atlantic White Cedar, which did not experience any weight loss. The softwood data did not show as clear a picture between weight loss, termite mortality, and specific gravity, mostly due to the SYP blocks (figure 1). There is, however, an apparent inverse relationship between specific gravity and termite mortality in softwood species. In general, our hypothesis that woods with a higher specific gravity have a greater natural resistance to degradation by *R. flavipes*, positively correlated with the recorded data of the hardwood species (figure 2). It was also observed that there was a higher percentage of termite deaths in bottles with woods of a higher specific gravity. It is important to note that these graphs are subjective based upon the wood species chosen for the experiment. Data from other species could yield a completely different trend.

FIGURE 1: The trends of specific gravity of softwoods on termite mortality and weight loss.



[n] - Letter designations for wood species are located between corresponding data points

FIGURE 2: The trends of specific gravity of tropical hardwoods on termite mortality and weight loss.



[n] - Letter designations for wood species are located between corresponding data points

Esenther's termite test (1977) on the natural resistance of 21 native and exotic woods also showed a positive correlation between specific gravity and resistance. Of the species tested, Esenther found the 7 exotic woods: Teak, Iroko, Mahogany, Australian cypress-pine, Niove, Greenheart, and *Holywood lignumvitae* to be most resistant, along with several native hardwoods: two oaks, Black locust, Osage-orange, and redwood (Esenther, 1977).

The relative age of the Alaska Yellow Cedar blocks tested did not seem to effect damage resistance. Thereby reducing the possibility that the extractives age with the dead wood making it more susceptible to degradation. Blocks 81IS and 80IS were less than five years old at the time of the test, and 22IS and 28IS blocks were over 20 years old. Alaska Yellow Cedar is listed as being resistant to very resistant to decay according to the *Wood Handbook (4)* (1999). A study done by DeGroot (2000) looked at the potential for utilizing dying and dead Alaska Yellow Cedar heartwood. He compared their durability to those trees still alive, and those that have been dead for many years. In testing them against decay fungi such as *G. trabeum*, he concluded that heartwood from living trees, and those that have been dead less than 80 years are adequate to have practical application for products used aboveground (DeGroot et al, 2000). Our Alaska Yellow Cedar blocks coincided with the classifications found in the *Wood Handbook (4)*(1999), showing "resistance to high resistance" against damage by termites.

TABLE 1: Results of the natural resistance of 12 species of native and exotic woods exposed to *R. flavipes*.

Evaluation of Termite Damage to Tropical and Non-Tropical Woods

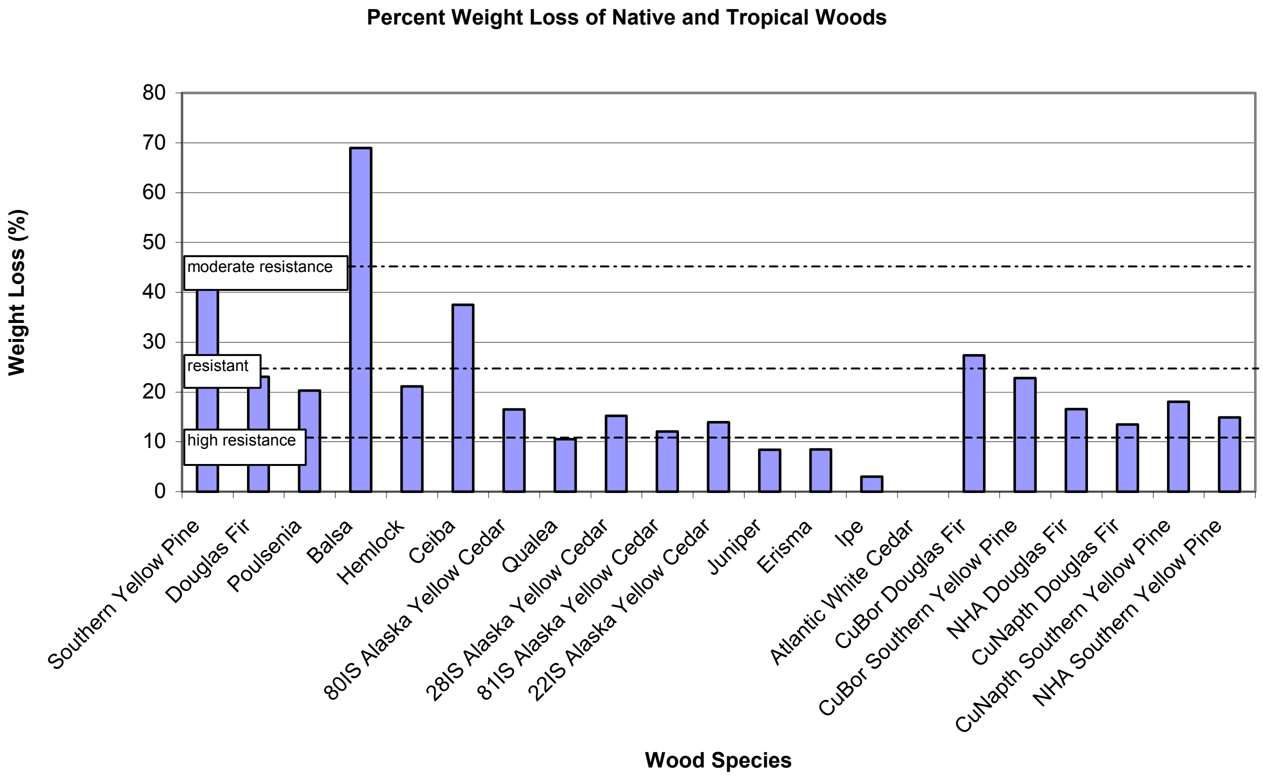
	Wood Blocks			Termites		
	Wood (h-hardwood/ s-softwood)	Mean wt loss (g)	Mean % wt loss [a]	Termite mortality (%)	Mean % termite mortality	Specific Gravity (oven dry wt/ green volume)
Untreated Wood Blocks	Southern Yellow Pine (s)	1.04 (0.4)	41.32 (15.3)	22.65	22.65 (19.1)	0.67
	Douglas Fir (s)	0.79 (0.2)	23.08 (5.8)	45.44	45.44 (18.2)	0.45 - 0.46
	Poulsenia (h)	0.74 (0.1)	20.27 (1.9)	79.4	79.40 (8.5)	0.33
	Balsa (h)	0.69 (0.2)	68.97 (25.7)	52.7	52.70 (17.6)	0.10 - 0.17
	Hemlock (s)	0.69 (0.3)	21.14 (13.1)	71.8	71.80 (25.8)	0.38
	Ceiba (h)	0.52 (0.1)	37.47 (5.2)	87.15	87.15 (18.1)	0.25
	80IS Alaska Yellow Cedar (s)	0.48 (0.0)	16.52 (1.1)	51.43	51.43 (5.0)	0.42
	Qualea (h)	0.47 (0.1)	10.54 (1.2)	86.24	86.24 (4.5)	0.49 - 0.60
	28IS Alaska Yellow Cedar (s)	0.46 (0.2)	15.21 (7.0)	54.27	54.27 (3.5)	0.42
	81IS Alaska Yellow Cedar (s)	0.42 (0.1)	12.05 (2.5)	61.43	61.43 (15.3)	0.42
	22IS Alaska Yellow Cedar (s)	0.33 (0.0)	13.91 (0.4)	60.23	60.23 (2.4)	0.42
	Juniper (s)	0.32 (0.0)	8.40 (1.0)	94.93	94.93 (2.7)	0.44
	Erisma (h)	0.23 (0.0)	8.50 (0.7)	80.15	80.15 (12.4)	0.46
	Ipe (h)	0.16 (0.1)	3.00 (0.5)	90.38	90.38 (7.1)	0.85 - 0.97
	Atlantic White Cedar (heartwood) (s)	0	0	100	100	0.35
Treated Wood Blocks	CuBor Douglas Fir	0.94 (0.3)	27.36 (7.4)	27.62	27.62 (26.9)	Na
	CuBor Southern Yellow Pine	0.60 (0.2)	22.80 (6.7)	66.3	66.30 (16.5)	Na
	NHA Douglas Fir	0.58 (0.2)	16.58 (6.1)	63.9	63.90 (24.0)	Na
	CuNapth Douglas Fir	0.48 (0.2)	13.48 (5.0)	66.92	66.92 (31.2)	Na
	CuNapth Southern Yellow Pine	0.44 (0.1)	18.05 (2.3)	60.62	60.62 (11.3)	Na
	NHA Southern Yellow Pine	0.36 (0.1)	14.91 (2.0)	80.32	80.32 (6.2)	Na

[a] mean (s.d.)

CuBor-treated Southern Yellow Pine blocks experienced half as much weight loss from termite damage as did the untreated SYP blocks. CuNaph and NHA-treated SYP blocks faired the best in the SYP group. Treated blocks in general did well, but in this study woods with a high natural durability did just as well, if not better. All treated blocks were recorded as resistant except CuBor-treated Douglas-fir that would be classified as moderately resistant. This most likely has to do with the fact that the higher density of Douglas Fir does not allow it to absorb treatments well (Flynn and Holder, 2001). NHA and Cu-Naph treated Douglas-fir did improve its resistance to termite attack. This shows the potential of NHA to protect woods that are more resistant to treatment. The results also show a possibility of a successful oil based preservative such as Cu-Naph.

According to the standard wood block test the untreated woods, Juniper, Erisma, Ipe, and Atlantic White Cedar had a high natural resistance (ASTM 2003). Douglas-Fir, Poulsenia, Hemlock, Alaska Yellow Cedar, and Qualea fell into the "resistant" category. Southern Yellow Pine and Ceiba results were found to be moderately resistant, while Balsa showed slight to no resistance (figure 3).

FIGURE 3: Percent weight loss of native and exotic, as well as treated wood species.



Timing of the termite testing may have played a role in the lack of measurable weight loss of Atlantic white cedar, which was done in the winter as opposed to the others which were performed in the summer months. In general, it has been our observation that results of termite feedings are directly correlated with Wisconsin's seasonality. Termite tests done in winter occasionally experience early mortality of the termites as well as less weight loss to the blocks. Therefore, the results obtained in testing Atlantic white cedar may be due in part to the seasonal timing of the termite test. However, according to the ASTM standard, if the termites live one week, they are considered robust enough to have a valid test, even late in the season (ASTM 1998).

Evaluation of natural termite resistance is becoming increasingly important in the wood preservation industry as there has been more of a focus in reducing the amount of chemicals being leached out of the wood and into the environment. In using these higher density woods in building projects one is reducing the amount of preservative needed to protect the wood as well as increasing its longevity.

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