Resistance of the Indonesian Woods Bangkirai (*Shorea laevis*) and Merbau (*Intsia palembanica*) to Formosan Subterranean Termite Attack

by

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ABSTRACT

Heartwood lumber from naturally-durable tree species offers alternatives to preservative-treated lumber for construction uses. In laboratory studies, we evaluated the resistance of bangkirai, *Shorea laevis* Ridl. (Family Diptocarpaceae), and merbau, *Intsia palembanica* Miq., (Family Caesalpinaceae) heartwood of Indonesian origin to attack by the Formosan subterranean termite, *Coptotermes formosanus* (Isoptera: Rhinotermitidae). Both no-choice tests, in which termites were presented with only a single wood wafer, and two-choice tests, in which termites were offered the choice of one of the two Indonesian woods or a wafer of susceptible Douglas-fir (*Pseudotsuga menziesii*), were performed. Bangkirai and mirbau proved to be extremely deterrent to termites, with performance comparable to preservative-treated wood.

Keywords: *Coptotermes formosanus*, tropical hardwoods, durable tree species.

INTRODUCTION

Construction materials used in Hawaii and other tropical and subtropical regions are exposed to severe risk of attack by subterranean termites. The Formosan subterranean termite, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae), in particular is a severe pest in many parts of the world, and other *Coptotermes* species are serious pests in the South Pacific, Australia, and Southeast Asia. In Hawaii, this termite is responsible for over $100 million in costs for control and damage repairs each year. In these regions, the ability of building materials to resist termite attack is a critical factor in architectural design and construction decisions.

Naturally-durable woods may be employed in building construction as an alternative to the more common use of non-durable timbers that have been pressure-impregnated with a wood preservative (Grace & Yates 1999, Grace 2003). For example, the durable wood *Chamaecyparis*

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nootkatensis (Alaska cedar or yellow cypress) is quite resistant to attack by the Formosan subterranean termite (Grace & Yamamoto 1994), and has been approved for construction use in Hawaii by local building departments. Western red cedar (*Thuja plicata*) and teak (*Tectona grandis*) also exhibit some degree of resistance to termite attack (Su & Tamashiro 1986, Grace & Yamamoto 1994, Grace *et al.* 1999). Surveys of tree species grown in Hawaii (Grace *et al.* 1996) and in Malaysia (Grace *et al.* 1998; Wong *et al.* 1998, 2001) have also identified a number of trees with potential for greater use in the termite-occupied tropics.

Both bangkirai, *Shorea laevis* Ridl. (Family Diptocarpaceae), and merbau, *Intsia palembanica* Miq., (Family Caesalpinaceae) are dense tropical hardwood species with favorable strength properties that have been reported to have some degree of resistance to both insects and decay fungi (Flynn & Holder 2001; Soerianegara & Lemmens 1994; Indonesia Dept. of Forestry, undated; Lopez 1984). As with almost all durable tree species, only the heartwood, and not the sapwood, of these species is reputed to be durable. The need to differentiate between heartwood and sapwood in specifying naturally durable woods for construction purposes is an important consideration.

In the present studies, wafers cut from bangkirai and merbau heartwood lumber (both of Indonesian origin) were evaluated for resistance to attack by Formosan subterranean termites in a rigorous laboratory test (American Wood-Preservers' Association Standard Method E1-97, which also fulfills the requirements of ASTM D 3345-74). This test consisted of both a no-choice (or single choice) assay, in which termites were provided with only a single sample of either bangkirai, merbau, or susceptible Douglas-fir (*Pseudotsuga menziesii*) upon which to feed; and a two-choice assay in which termites had the option of feeding upon either one of the two Indonesian woods or a Douglas-fir wafer. In both cases, each replicate with each individual wood sample was exposed to 400 termites for a 4-week (28-day) period. This test represents severe termite exposure, since the termites are freshly collected from field locations immediately before the test, and then kept under warm and humid conditions ideal for survival and feeding. Typically, Douglas-fir wafers are virtually destroyed in the 4-week test period.

MATERIALS AND METHODS

Bangkirai (*Shorea laevis*) and merbau (*Intsia palembanica*) of Indonesian origin were tested separately. Bangkirai samples were provided by HALE (Habitat and Living Environments) LTD, Honolulu; and merbau samples were provided by B&P North Shore LLC, Honolulu. In both cases, cross-sawn test wafers were prepared from heartwood lumber in the standard test wafer dimensions of 1 × 1 × 1/4-inch specified in AWPA Standard Method E1-97 (AWPA 2003). For purposes of comparison, equivalent wafers were also cut from Douglas-fir (*Pseudotsuga menziesii*) heartwood boards. Douglas-fir is the most common construction timber used in Hawaii, and is quite susceptible to termite attack.

Wafers were oven-dried (90° C, 24 hours) to obtain dry weights prior to termite exposure. Two tests were conducted: (1) a no-choice (or single-choice) test in which termites were presented either with a single wafer of bangkirai, merbau or susceptible Douglas-fir, and (2) a two-choice test in which a wafer of one of the two Indonesian woods was paired with a wafer of Douglas-fir within a single test container, thereby offering a choice of food to the termites.

For the no-choice test, a single dry wood wafer was placed on the surface of 150 g of damp silica sand (moistened with 30 ml distilled water) inside a screw-top jar (8 cm diameter, 10 cm high). For the two-choice test, a wafer of either bangkirai or merbau was paired with a Douglas-fir wafer within a similar test container, under the same conditions as the no-choice test.

Formosan subterranean termites, *Coptotermes formosanus* Shiraki, were collected from active field colonies on the Manoa campus of the University of Hawaii (for merbau tests) and on the grounds of the Poamoho Experiment Station (for bangkirai tests) immediately before the laboratory tests using a trapping technique (Tamashiro *et al.* 1973). A total of 400 termites (360 workers and 40 soldiers, to approximate natural caste proportions in field colonies) were added to each test jar. Both the no-choice and two-choice tests were replicated 10 times with each wood species. We also included additional wafers of each material as "environmental controls," exposed to the same test conditions as the other wafers, but without addition of any termites to the jar, in order to recognize any weight change in the wafers due to absorbing moisture or any other factors unrelated to termite attack.

After adding termites, the jars were placed in an unlighted controlled-temperature cabinet at 28° C for 4 weeks (28 days), as specified in AWPA E1-97. Each jar was inspected weekly for evidence of termite activity in the soil and on the test materials. At the conclusion of the 4-week test period, percentage termite mortality was recorded, the wafers were rated visually according to a 0-10 scale (where 10 is sound, 9 is light attack, 7 is moderate attack and penetration, 4 is heavy attack, and 0 is total failure of the wood sample) specified in AWPA E1-97 and ASTM D 3345-74, and the oven dry weight change was recorded for each wafer.

RESULTS AND DISCUSSION

In both no-choice and choice tests, the susceptible Douglas-fir wafers were virtually destroyed by termite feeding over the 4-week test period (Tables 1, 2). The bangkirai and merbau wafers, however, were largely untouched, with most samples in all tests rated as "10" on a visual scale of 0-10, and none rated less than "9" (indicating slight surface abrasions by the termites).

Table 1. Results of no-choice and two-choice 4-week laboratory evaluations of the resistance of Indonesian bangkirai (*Shorea laevis*) to Formosan subterranean termite attack.

Test	Wood	Mean Visual Rating[a]	Grams Mass Loss[b]	Percent Mass Loss[b]	Percent Termite Mortality[b]
No-choice	Bangkirai	9.80	0.04 (0.02)	1.25 (0.48)	28.73 (2.16)
	Douglas-fir	1.20	1.05 (0.14)	53.19 (11.91)	19.55 (3.55)
Two-choice	Bangkirai	9.80	0.00 (0.02)	0.00 (0.49)	
	Douglas-fir	0.80	1.17 (0.18)	64.95 (16.56)	12.90 (2.54)

[a]Visual rating on scale of 10 (sound) to 0 (failure).
[b]Standard deviations in parentheses.

Table 2. Results of no-choice and two-choice 4-week laboratory evaluations of the resistance of Indonesian merbau (*Intsia palembanica*) to Formosan subterranean termite attack.

Test	Wood	Mean Visual Rating[a]	Grams Mass Loss[b]	Percent Mass Loss[b]	Percent Termite Mortality
No-choice	Merbau	9.50	0.18 (0.05)	7.01 (2.45)	35.10 (4.28)
	Douglas-fir	0.80	0.92 (0.12)	39.82 (9.75)	21.60 (3.83)
Two-choice	Merbau	10.00	0.04 (0.01)	1.44 (0.48)	
	Douglas-fir	1.60	0.83 (0.15)	37.66 (9.58)	19.85 (4.01)

[a]Visual rating on scale of 10 (sound) to 0 (failure).
[b]Standard deviations in parentheses.

While the Douglas-fir wafers lost approximately half their mass to termite feeding during the 4-week period, the bangkirai and merbau wafers lost only about 1% and 7%, respectively, in the no-choice test in which termites had no option but to either feed on the single wood species available or die (Tables 1, 2). Clearly, both wood species were quite deterrent to foraging termites. Mortality of termites exposed to bangkirai and merbau slightly exceeded that of those fed upon Douglas-fir, which is likely explained by starvation due to feeding deterrence.

In the two-choice tests, the deterrence of both Indonesian wood species was even more apparent (Tables 1, 2). Neither bangkirai nor mirbau suffered mass losses greater than 1%, while the Douglas-fir wafers were, again, severally attacked. Termite mortality was low, and comparable to that observed in the no-choice tests with Douglas-fir alone.

These very high visual ratings and negligible weight losses demonstrate that bangkirai and merbau heartwood are comparable in terms of termite resistance to Alaska cedar and teak (Grace & Yamamoto 1994), and also compare favorably with lumber treated with the commonly-used preservatives CCA (rated 9-10 by Grace 1998) and disodium octaborate tetrahydrate (rated 7-10 by Grace & Yamamoto 1994). It is important to note, though, that it is generally only the heartwood, and not the sapwood of durable tree species that is termite and decay resistant. In fact, the sapwood of bangkirai is reported to be nondurable (Lopez 1984). Thus, for construction purposes, heartwood lumber should be specified.

These evaluations were performed with bangkirai and merbau lumber of Indonesian origin. *Shorea laevis* and *Intsia palembanica* are also harvested in other countries, and are known by a number of other regional common names. Timber harvested in other countries may also be termite resistant, and both *S. laevis* and *I. palembanica* from Malaysia have indeed been reported locally to be quite durable (Lopez 1984; Soerianegara & Lemmens 1994). However, site specific differences in the environment, soil conditions, and age of trees at harvest have been shown to influence the amount of heartwood in durable trees and the extractive content of that heartwood. Both of these factors can have an impact upon termite resistance. For example, teak from Laos, Burma, and Indonesia has been reported to be very durable, while teak from younger trees harvested in Malaysia was less durable (Grace *et al.* 1998, Martawijaya 1965). Thus, it would be a wise precaution to evaluate the insect and decay resistance of lumber from its specific country of origin prior to importation for construction purposes.

In conclusion, these evaluations demonstrate that bangkirai (*Shorea laevis*) and merbau (*Intsia palembanica*) heartwood lumber from Indonesia are both extremely resistant to termite attack. Such naturally-durable timbers are viable alternatives to preservative-treated lumber for construction use in Hawaii and other regions inhabited by the Formosan subterranean termite, so long as care is taken to specify heartwood lumber and to minimize any sapwood content.

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