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Termite Resistance of Malaysian and Exotic Woods with Plantation Potential: Laboratory Evaluation

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ABSTRACT

The resistance of selected Malaysian woods to attack by the representative aggressive subterranean termite *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) was evaluated in four-week, no-choice laboratory tests. This is part of an ongoing effort between the Forest Research Institute Malaysia and the University of Hawaii to document the termite resistance of Malaysian timber species of potential value in plantation forestry. Several of these tree genera also occur in Hawaii, or could potentially be of value as well in forestry efforts in the Hawaiian islands. Species included in the present report are: acacia (*Acacia mangium*), batai (*Albizia falcataria*), casuarina pine (*Casuarina equisetifolia*), Araucarian pine (*Araucaria cunninghamii*), sentang (*Azadirachta excelsa*), both Malaysian-grown and Burmese-grown teak (*Tectona grandis*), kempas (*Koompassia malaccensis*), tualang (*Koompassia excelsa*), Caribbean pine (*Pinus caribaea*), Scots pine (*Pinus sylvestris*), and rubberwood (*Hevea brasiliensis*). Of these, Burmese teak, kempas, tualang, and casuarina pine proved most resistant to termite attack. Malaysian teak and sentang demonstrated somewhat less, but still significant termite resistance. Sentang is a relatively pest-free tree of interest for plantation forestry, and was also quite toxic to termites. The remaining tree species were very susceptible to termite attack, and would require protection in the field and treatment of the resulting wood products. Correlation of these laboratory results with data from field studies in Malaysia will provide a comprehensive profile of the termite resistance of these timbers.

Key Words: Isoptera, Rhinotermitidae, teak, natural durability, wood extractives, *Coptotermes formosanus*, *Azadirachta excelsa*

INTRODUCTION

A number of tree species are of increasing interest in Malaysia as candidates for increased use and cultivation as plantation species. This subject is also of interest in Hawaii, where declining cultivation of sugar cane and pineapple has opened large blocks of land for alternative crops and forestry. Throughout the tropical Pacific region, the potential for damage by termites is an important consideration in both the selection and growth of plantation species and the manufacture and use of the resulting wood products.

Malaysia has a rich termite fauna, including several species of *Coptotermes* Wasmann (Tho 1992). The Hawaiian islands, on the other hand, are known to have only six termite species at present. However, one of these species is the notorious Formosan subterranean termite, *Coptotermes formosanus* Shiraki, which accounts for over US$ 100 million in costs of damages and control in Hawaii each year (Tamashiro 1990), and is considered to one of the single most destructive structural pests in the world (Su & Tamashiro 1987).

This report represents part of an on-going collaborative effort between the Forest Research Institute Malaysia (FRIM) and the University of Hawaii to document the in-ground termite resistance of potentially useful Malaysian timbers (Grace *et al.* 1998, Wong *et al.* 1998). Several of these represent genera which are also found in Hawaii (Little & Skolman 1989), and these genera and certain of the Malaysian species are also of interest to the Hawaiian forestry industry, as are other termite-resistant woods (Grace *et al.* 1996, Grace & Tome 1996). For example, acacia (*Acacia mangium*) and casuarina pine (*Casuarina equisetifolia*) are found in both locations. Teak (*Tectona grandis*) is of interest throughout southeast Asia and the Pacific, and Laotian teak has been reported to be quite resistant to *C. formosanus* (Grace & Yamamoto 1994). Sentang (*Azadirachta excelsa*) has attracted interest in Malaysia as a promising plantation species (Ahmad Zuhaidi & Mohd. Noor 1996, Ahmad Norani 1997), while the bark of the closely related neem tree (*Azadirachta indica*) has been shown to be have some termite-deterrent properties (Delate & Grace 1995).

In the present research project, we are performing laboratory evaluations of the selected wood species (primarily heartwood, since sapwood rarely resists termites or decay) against the Formosan subterranean termite at the University of Hawaii, using standard laboratory methodology (AWPA 1997, Grace 1998). Field evaluations of these same woods, using an accelerated in-ground procedure, are performed at FRIM, and these results will be reported elsewhere (Grace *et al.* 1998, Wong *et al.* 1998). The important structural pest *Coptotermes curvignathus* Holmgren is prevalent at the FRIM field site, and several other subterranean species are also present.

MATERIALS AND METHODS

For laboratory evaluations, 2×2×2 cm blocks were cut from the heartwood of the selected timber species (with the exception of sapwood from rubberwood and Scots pine, and samples where the heart-sap interface could not be determined in Araucarian and Caribbean pine,). Species included in this report are: acacia (*Acacia mangium*), batai (*Albizia falcataria*), casuarina pine (*Casuarina equisetifolia*), Aruacarian pine (*Araucaria cunninghamii*), sentang (*Azadirachta excelsa*), both Malaysian-grown and Burmese-grown teak (*Tectona grandis*), kempas (*Koompassia malaccensis*), tualang (*Koompassia excelsa*), Caribbean pine (*Pinus caribaea*), Scots pine (*Pinus sylvestris*), and rubberwood (*Hevea brasiliensis*).

These wood samples were subjected to a four-week, no-choice laboratory bioassay (AWPA 1997, Grace 1998). This bioassay includes (1) visual ratings of the test blocks using the scale of 10 (sound, surface nibbles permitted), 9 (light attack), 7 (moderate attack), 4 (heavy attack), or 0 (failure); (2) evaluation of the ovendry wood mass; and (3) evaluation of termite mortality.

Formosan subterranean termites, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) were collected from an active field colony on the Manoa campus of the University of Hawaii immediately before their use in laboratory assays, using a trapping technique (Tamashiro *et al.* 1973). Test containers were 80 mm diameter by 100 mm high screw-top jars, each containing 150 g washed and oven-dried silica sand and 30 ml distilled water. The test blocks were oven-dried (90°C for 24 hours), weighed, and allowed to equilibrate to laboratory conditions for several hours before test initiation. One test block was then placed on the surface of the damp sand, and 400 termites (360 workers and 40 soldiers, to approximate natural caste proportions) were added to each jar. Each wood species was replicated five times; and three samples of each species were also included as exposure controls, subjected to the same test conditions but with no termites present. Jars were placed in an unlighted controlled-temperature cabinet at 28±0.5°C for four weeks (28 days). At the conclusion of the test, percentage termite mortality was recorded, the blocks were visually rated according to the 0-10 scale, and the oven-dry mass change was measured for each block (adjusted by the average mass change, if any, of the control samples).

RESULTS AND DISCUSSION

Visual ratings of the test samples, mass losses, and termite mortality are represented in Table 1. Burmese teak had the highest order of termite resistance (visual rating of 9.75, mass loss of 0.76%), which is equivalent to the high durability of Laotian teak demonstrated by Grace & Yamamoto (1994), and in contrast to the more moderate level of resistance demonstrated by the Malaysian teak samples (visual rating of 5.80, mass loss of 5.75%). This difference may be attributable to the greater age and tree diameter of the Burmese and Laotian teak stands, although attempts to correlate documented site-specific differences in teak extractive content with tree diameter have not been too successful to date (Simatupang *et al.* 1995).

Both *Koompassia malaccensis* (kempas) and *K. excelsa* (tualang) also proved quite resistant to attack, as did *Casuarina equisetifolia* (casuarina pine). Feeding on *K. malaccensis* caused the greatest termite mortality (90%), while teak and the other two very resistant woods elicited mortality in the range of 48-61%. In field evaluations at FRIM, *Koompassia* spp. have not performed as well as observed in the laboratory test (Wong *et al.* 1998), possibly due to leaching of extractives under field conditions, or the presence of different (and multiple) termite species at the field location. It is also possible that termites foraging on a variety of woods in the natural setting may not accumulate the toxins apparently found in *Koompasssia* as readily as insects in a no-choice laboratory test.

Table 1. Results of a four-week, no-choice laboratory test of heartwood[1] of potential tropical plantation trees exposed to 400 Formosan subterranean termites.

Tree Species	Local Name	Mean Visual Rating[2]	Mean mg Mass Loss (± SD)	Mean % Mass Loss (± SD)	Mean Termite Mortality (± SD)
Tectona grandis (Burma)	Teak	9.75	34.21 (3.17)	0.76 (0.10)	49.10 (3.62)
Tectona grandis (Malaysia)	Teak	5.80	279.67 (140.10)	5.75 (3.04)	61.20 (14.91)
Casuarina equisetifolia	Casuarina pine	9.00	224.25 (65.01)	2.94 (0.98)	53.45 (4.27)
Koompassia malaccensis	Kempas	9.00	171.79 (141.58)	2.84 (2.50)	90.10 (22.14)
Koompassia excelsa	Tualang	8.20	279.29 (38.46)	4.85 (0.43)	47.80 (13.07)
Azadirachta excelsa	Sentang	5.80	202.77 (94.22)	4.45 (2.16)	82.35 (18.60)
Araucaria cunninghamii	Araucarian pine	3.80	577.27 (18.05)	18.05 (8.53)	52.90 (21.47)
Hevea brasiliensis	Rubberwood	1.60	843.67 (149.07)	19.98 (3.72)	16.55 (4.98)
Pinus caribaea	Caribbean pine	2.40	958.26 (134.10)	26.63 (3.56)	29.13 (9.46)
Pinus sylvestris	Scots pine	0.80	1251.77 (265.85)	28.88 (6.21)	8.65 (4.88)
Acacia mangium	Acacia	0.80	887.12 (185.25)	24.94 (7.11)	21.13 (8.33)
Albizia falcataria	Batai	0.00	505.62 (42.77)	27.23 (3.51)	36.50 (6.54)

[1]Exceptions were sapwood samples from rubberwood and Scots pine, and undetermined samples from Araucarian and Caribbean pine.

[2]Visual ratings according to AWPA scale of 10 (sound, surface nibbles permitted), 9 (light attack), 7 (moderate attack), 4 (heavy attack), or 0 (failure).

Interestingly, *Azadirachta excelsa* (sentang) proved very toxic to the termites (mean 82% mortality), although it was not the most resistant species to attack. The durability of this wood was not insignificant, however, falling between that demonstrated by *K. malaccensis* and Malaysian teak. Sentang is a relatively pest-free tree, and has characteristics that are quite promising for plantation growth (Ahmad Zuhaidi & Mohd. Noor 1996, Ahmad Norani 1997). The principal obstacles to increased planting of *A. excelsa* are variation in seed germination rates (Lim & Shaji 1996) and heterogenous growth patterns, resulting in distinct variation in tree sizes within even-aged stands (Ahmad Zuhaidi & Mohd. Noor 1996). However, the fairly high degree of termite resistance demonstrated in the present study certainly contributes to its potential.

Araucaria cunninghamii also proved fairly toxic to the termites forced to feed upon it (mean 53% mortality), but this did not deter them from doing substantial damage. The two true pines, *Pinus caribaea* and *P. sylvestris*, were also very susceptible to termite attack, although *P. caribaea* was also slightly toxic. Although extractives toxic to termites are certainly present in some species of pines (c.f., Grace *et al.* 1989), termite resistance appears to demand that such extractives both be present in sufficient concentration and be capable of off-setting the presence of feeding stimulant chemicals in the wood (Grace 1997).

Rubberwood, acacia, and batai (*Albizia falcataria*, also known as Molucca albizia) were all very susceptible to termite feeding, and would thus likely require protection as seedlings and treatment of the resulting wood products. Other studies (Grace *et al.* 1996, Grace & Tome 1996) have also demonstrated the susceptibility of *A. falcataria* grown in Hawaii to attack by *C. formosanus*.

This paper represents a progress report on work in progress. It is hoped that the results of these laboratory evaluations and the corresponding field trials (Grace *et al.* 1998, Wong *et al.* 1998) will aid both plantation forestry in Malaysia and efforts to promote forestry as a viable and diverse industry in the Hawaiian islands.

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