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

Andrew H.H. Wong[1], J. Kenneth Grace[2] and Laurence G. Kirton[1]

[1]Forest Research Institute Malaysia (FRIM)
Kepong, Selangor
52109 Kuala Lumpur, Malaysia

[2]Department of Entomology
College of Tropical Agriculture & Human Resources
University of Hawaii at Manoa
3050 Maile Way
Honolulu, HI 96822-2271, USA

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Andrew H.H. Wong[1], J. Kenneth Grace[2] and Laurence G. Kirton[1]

[1]Forest Research Institute Malaysia (FRIM), Kepong, Selangor
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[2]Department of Entomology, College of Tropical Agriculture & Human Resources
University of Hawaii at Manoa, 3050 Maile Way, Honolulu, HI 96822-2271, USA

Abstract

An in-ground resistance of selected Malaysian and exotic timbers to attack by a representative aggressive subterranean *Coptotermes* termite was evaluated as part of an on-going collaborative research between the Forest Research Institute of Malaysia and the University of Hawaii on termite control of building timbers under humid tropical conditions. A test site at FRIM, highly susceptible to the subterranean termite *Coptotermes curvignathus* was chosen for study. The accelarated test protocol consisted of burying small (2 x 2 x 2 cm) wood blocks of the following timber species at 15-20 cm below-ground with the immediate environment manipulated by addition of residues from oil palm fibres and venners of decay susceptible woods and concealed with forest top soil: *Casuarina equisetifolia*, *Azadirachta excelsa*, *Tectona grandis* (both Malaysian-grown and Burmese material), *Hevea brasiliensis*, *Acacia mangium*, *Albizia falcataria*, *Araucaria cunninghamii*, *P. sylvestris*, *Koompassia malaccensis and K. excelsa*. After 28 days, it was found that the results of the subterranean termite resistance test are consistent with the known/expected termite resistance of these woods when compared with previous natural durability stake test records of FRIM.

Keywords: Subterranean termites, Natural durability, Termite resistance, Accelerated in-ground field tests, *Coptotermes curvignathus*, Tropical timbers

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INTRODUCTION

In the tropics, termites, particularly the subterranean species, poses a far more serious threat to building timbers than decay fungi. In Malaysia termite infestations have also caused severe losses to important agricultural crops such as sugar-cane, rubber trees, oil palm and forest plantation trees (Tho 1975, Tho & Kirton 1990). Indeed termites are known to cause more damage to woody and ligno-cellulosic materials than perhaps any other tropical insect groups (Tho & Kirton 1990).

Subterranean termites, particularly species of *Coptotermes*, are widely recognized pests of timbers in buildings in Malaysia (Tho & Kirton 1990, Kirton & Wong 1996). The timber species recommended for various building components are distinctly variable in wood quality, being largely grouped according to wood density and/or wood strength classes. Thus under the Malaysian Grading Rules for sawn hardwood timbers (Anon. 1984) Malaysian hardwoods are categorized into 3 density groups (heavy hardwoods, medium hardwoods and the light hardwoods), being directly associated with strength groups and natural durability classes, i.e., a tendency for the stronger and higher in-ground durability timbers to comprise the medium-to-heavy hardwoods (Jackson 1957, Mohd. Dahlan & Tam 1985, 1987). Certainly the highly variable wood quality among Malaysian hardwoods would expectedly impart differential subterranean termite resistance under service conditions.

In-ground durability FRIM test results reflect a mixed fungal and termite degradation of the test wood species, although subterranean termites are regarded to cause the most damage to the wooden stakes than fungi (Foxworthy & Wooley 1930). In buildings, however, incidences of termite attack of wood are often predominant unlike fungal decay, often in the absence of decay fungi. It is thus of practical importance to evaluate the actual subterranean termite resistance *per se* of Malaysian hardwoods, including timbers with plantation potential. An approach to examining termite resistance has been the use of laboratory test procedures although in some cases the test termites used are not indigenous to Malaysia (Thomas 1953, Jackson 1954, Creffield & Tam 1979, Ahmad Said *et al* 1982, Grace *et al* 1988a, 1998b). Alternatively, an accelerated in-ground termite test procedure for determining wood durability was recently examined at a FRIM test site (Grace *et al* 1998a) where *Coptotermes curvignathus* is known to be prevalent. This paper represents part of an on-going collaborative research between FRIM and the University of Hawaii to document the subterranean termite resistance of potentially useful Malaysian timbers (Grace *et al* 1998a, 1998b).

MATERIALS AND METHODS

Heartwood blocks, 2 x2x2 cm, were prepared from the following timber species: acacia (*Acacia mangium*), batai (*Albizia falcataria=Paraserianthes falcataria*), casuarina pine (*Casuarina equisetifolia*), Araucarian pine (*Araucaria cunninghamii*), sentang (*Azadirachta excelsa*), both the Malaysian-grown and Burmese-grown teak (*Tectona grandis*), kempas (*Koompassia malaccensis*) and tualang (*Koompassia excelsa*). Sapwood blocks were obtained from rubberwood (*Hevea brasiliensis*) while for Scots pine (*Pinus sylvestris*) blocks were cut from material in which the heartwood could not be clearly distinguished. The blocks were oven dried (80°C) overnight and weighed. The blocks were subjected to a four-week in-ground bioassay at a FRIM test site during a period of almost daily rainfall. The chosen field site is in a forested area, well-drained, shaded, moist and of high subterranean termite activity. The design of the field test protocol is as follows: a ditch of consistently 15-20 cm depth is dug to partly layered with residues from oil palm (*Elaeis guineensis*) fibres and susceptible wood veneers (to bait and aggregate termites). Wood blocks were then placed about this depth above the residue layer and additional amounts of residues added to conceal the blocks, and the ground covered with top soil.

The blocks (5 replications) were kept together according to species to aid identification of the specimens at the end of test.

After four weeks, the ground was unearthed, the blocks carefully retrieved, weighed immediately to determine the final wet weight and then oven dried. Determinations of final block moisture contents (% g/g), absolute mass loss (in mg) and percentage mass loss (% g/g).

The test blocks were also rated according to an arbitrary 0-5 visual rating scale as follows: 0=sound, 1=surface nibbles, 2=light attack, 3=moderate attack with bore holes, 4=heavy/severe attack, and 5=completely destroyed. Where available, existing in-ground natural durability ratings previously compiled at FRIM (Foxworthy & Wooley 1930, Jackson 1957, Mohd Dahlan & Tam 1985, 1987, Mohd. Dahlan & Azlan 1994) for the timber species were also included for comparison with the present test results. When the soil was unearthed after four weeks, *Coptotermes curvignathus* was captured within. Repeated sampling of the termite fauna also noted the presence of other termites at the FRIM site.

RESULTS AND DISCUSSION

The accelerated subterranean termite resistance assessments (from wood blocks) for the eleven wood species, both as visual ratings and wood mass losses, are presented in Table 1 alongside with the final moisture contents of the degraded wood blocks and known/predicted FRIM in-ground durability ratings (from wooden stakes). It appears that the final wood moistures were not associated with termite degradation of the wood, while a general trend among the three parameters of termite degradation (visual rating, absolute mass loss & percentage mass loss) among the eleven woods was found, i.e., low ratings with low mass losses (Table 1). It might be expected that where for certain woods, the present visual ratings and mass losses contrasted against the existing FRIM in-ground durability ratings for that wood species, this could be due to inherent differences between the accelerated field wood block test and the traditional FRIM field stake test protocols.

The wood of *Tectona grandis* (teak) grown in Malaysia (visual rating: 0, mass loss: ca. 1%) and Burma (visual rating: 0, mass gain: ca. 8%) were rated as very durable against termites. These ratings were better than the FRIM in-ground rating of "durable" given to teak samples from Burma and Thailand (Foxworthy & Wooley 1930, Mohd. Dahlan & Tam 1987). Both Burmese and Laotian teak were rated as very resistant to *Coptotermes formosanus* in the laboratory no-choice test except for Malaysian teak (Grace & Yamamoto 1994, Grace *et al* 1998a). Elsewhere however, teak was reported to be moderately durable against *Microtermes insperatus* (Suhirman & Eaton 1984). Such variations in teak wood durability may be directly associated with tree and also varies between juvenile and mature heartwood (Martawijaya 1965, Rudman *et al* 1967). Laboratory test by Rudman *et al* (1967) against *Coptotermes lacteus* also reported a parallel trend of radial variation in termite resistance (i.e. high resistance of outer versus inner heartwood) with decay resistance reported for teak and many other timbers (e.g. Rudman 1964, Rudman *et al* 1967, Wong *et al* 1983).

Indeed it is realized from previous studies that teak is not consistently immune to termite degradation in the tropics, and therefore a reputation of high durability of this species elsewhere does not necessarily mean the same under a termite hazard in different localities. Hence given the variable termite resistance of teak overall, it would not be surprising that *Coptotermes curvignathus* is reported as a teak pest in Malaysia (Dhanarajan 1969) or Indonesia (Suratmo 1982). Nevertheless the in-ground durability (and termite resistance) of teak is generally reported as being high, which is attributed to the anthraquinone component in teak extractives exhibiting both clonal and provenance variations (Simatupang *et al* 1995)

Both *Casuarina equisetifolia* (casuarina pine) (visual rating: 0.2, mass gain: 0.2) and *Azadirachta excelsa* (sentang) (visual rating: 0.8, mass gain: 33%) were also found to be termite resistant, in the same class as teak from the two sources (Table 1), while the same result was found for *C. equisetifolia* challenged against *Coptotermes formosanus* (Grace *et al* 1998a). However *C. equisetifolia* FRIM test stakes were found to be "moderately durable" (Mohd. Dahlan & Tam 1985, 1987), while stake test records are not yet available for sentang. The resistance of sentang to *C. formosanus* was comparable to Malaysian teak (Grace *et al* 1998a) but ranked considerably more termite resistant than Malaysian teak in the present accelerated field test (Table 1). A possible explanation for the observed termite resistance of sentang may be found with the related species *Azadirachta indica* (neem), in which the bark of neem tree was found to possess some termite-repellant properties (Delate & Grace 1995), while the chemical azadirachtin isolated from neem seeds possess insecticidal properties (Jacobson 1986). Also, neem wood grown in Bangladesh is naturally durable (Lahiry 1994). The observations of both the termite resistance of sentang from Malaysian and Hawaiian tests, and the relatively pest-free nature of sentang trees, would largely support the potential of this species for forest plantations in Malaysia (Ahmad Zuhaidi & Mohd. Noor 1996).

The wood of the genus *Koompassia* had low termite resistance compared with teak, casuarina pine and sentang (Table 1). Nevertheless the resistance of *K. malaccensis* (kempas) was better (visual rating: 3.9, mass loss: 18.1%) than that of *K. excelsa* (tualang) where all the replicate blocks of the latter were completely consumed after four weeks (visual rating: 5, mass loss: 100%). These results for *Koompassia* woods supported their FRIM in-ground natural durability ratings of non-durable or moderately durable wood (Foxworthy & Wooley 1930, Mohd Dahlan & Tam 1985, 1987) and also the known susceptibility of tualang to *Coptotermes curvignathus* (Dhanarajan 1969). By contrast, against to *C. formosanus*, both species of *Koompassia* proved quite resistant (Grace *et al* 1998b) while kempas was moderately resistant to *C. curvignathus* (Ahmad Said *et al* 1982). Again these findings demonstrate that the choice of test protocols used to evaluate termite resistance of *Koompassia* woods may elicit the different wood-feeding activities of the test termite species (Grace *et al* 1998b).

Table 1. Results of a four-week accelerated in-ground termite test of wood species at FRIM

Wood species	Local name	Mean MC[1] (% g/g)	Mean visual rating[2]	Mean ML[3] (mg)	Mean ML (% g/g)	Natural durability rating[4]
Tectona grandis (Malaysian)	Teak	104	0	47	0.8	2
Tectona grandis (Burmese)	Teak	124	0	-56.6	-7.8	2
Casuarina equisetifolia	Casuarina pine	55	0.2	-17	-0.2	3
Azadirachta excelsa	Sentang	101	0.8	-33	-0.7	2?
Albizia falcataria	Batai	74	3.2	960	11.2	3?
Koompassia malaccensis	Kempas	64	3.9	1115	18.1	3 - 4
Acacia mangium	Acacia	113	4.8	745	23	3 - 4?

Pinus sylvestris	Scots pine	CC[5]	5	4336	100	4?
Araucaria cunninghamii	Araucarian pine	CC	5	3411	100	4?
Koompassia excelsa	Tualang	CC	5	6058	100	3 - 4
Hevea brasiliensis	Rubberwood	CC	5	4369	100	4

1) MC=moisture content of wood blocks immediately after test

2) Termite resistance rating scale of 0 (sound) to 5 (destroyed)

3) ML=mass loss of wood blocks in absolute or precentage values

4) In-ground natural durability FRIM rating scale of 1 (very durable: >10yrs), 2 (durable: 5-10 yrs), 3 (moderately durable: 2-5 yrs) and 4 (non-durable: <2yrs). ?=Natural durability these woods were not examined and therefore predicted ratings are given instead

5) CC=completely consumed by termites

The softwoods *Araucaria cunninghamii* and *Pinus sylvestris* proved to be completely susceptible to subterranean termites (replicated wood blocks lost after four weeks, Table 1). These findings supported observations of the susceptibility of plantation-grown exotic softwoods (*A. cunninghamii* and *P. caribaea*) in Malaysia and Indonesia to *Coptotermes curvignathus* (Dhanarajan 1969, Thapa & Shim 1971, Natawiria 1974, Tho 1975), of the low in-ground durability of softwoods (*Agathis alba*, *A. borneensis*, *Pinus caribaea*, & *P. insularis*) in the humid tropics (Jackson 1957, Suhirman & Eaton 1984, Mohd. Dahlan & Tam 1985, 1987)) and of their low resistance (*A. cunninghamii*, *P. sylvestris* & *P. caribaea*) against *Coptotermes formosanus* in the laboratory (Grace *et al* 1998b). These woods were easily degraded despite the toxicity of some of the resinous extractives against termites (Grace *et al* 1989, Grace *et al* 1998b), the contents of which may be insufficient to override the presence of feeding stimulant chemicals in the wood (Grace 1997).

The hardwoods *Hevea brasiliensis* (rubberwood), *Acacia mangium* (acacia) *and Albizia falcataria* (batai) were found to be susceptible to subterranean termites (Table 1). Rubberwood blocks were completely degraded and was clearly non-durable or termite-susceptible (Ridley 1904, Lahiry 1994, Grace *et al* 1998a). However, in-ground FRIM stake tests (Mohd. Dahlan & Tam 1987) and laboratory tests against *Coptotermes curvignathus* (Ahmad Said *et al* 1982) reported rubberwood to be respectively moderately durable and moderately termite resistant.

The natural durability (and associated termite resistance) of wood species within the genera *Acacia* and *Albizia* varies considerably (Roonwal 1979, Lahiry 1994, Bhat 1997). The wood of *Albizia falcataria* was rated as moderately termite resistant in the present study (visual rating: 3.2, mass loss: *ca.* 11%), similar to the FRIM (Mohd. Dahlan & Tam 1985) in-ground evaluation for another species of batai (*A. moluccana*). However the wood was rated as very durable in-ground contact against *Microtermes insperatus* and *Schedorhinotermes javanicus* in Indonesia (Suhirman & Eaton 1984) or even non-durable elsewhere (Bhat 1997). The wood was found to be susceptible to *Coptotermes formosanus* in the laboratory (Grace & Tome 1996, Grace *et al* 1998a). *Acacia mangium* was susceptible to subterranean termites in this study (visual rating: 4.8, mass loss: 23%) with low in-ground durability in Bangladesh (Lahiry 1994). This explains why *C. curvignathus* is found to attack and kill standing trees of *A. mangium* in some plantations in Malaysia (Chey 1997, Tho & Kirton 1990, Intachat & Kirton 1997).

The present in-ground field test protocol described using small wood specimens is an attempt to provide an accelerated test (target duration of several weeks cf. Several years for the FRIM in-ground stake tests). The test is not necessarily full-proof as yet although the results presented in this study demonstrates the potential of such a termite test protocol. As an on-going collaborative research to document the subterranean termite resistance of Malaysian woods, the choice FRIM site will be sampled to determine the relative dominance of different termite species occurring at the site. So far, *Coptotermes curvignathus*, *Odontotermes* sp. and other species are found. Refinements to the present test will also be necessary to optimize termite aggregation, eg. influence of different susceptible cellulosic matrices, foraging depths, pre-aggregation of the test area by termites prior to introducing the test blocks, and duration of soil-burial. It is hoped that the development of such an accelerated termite test protocol would help provide an informed choice of suitable Malaysian timbers for use in situations of risk from subterranean termites.

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