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Laboratory Evaluation of Termite Resistance of Five Lesser-known Malaysian Hardwoods Used for Roof and Ceiling Construction

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Laboratory Evaluation of Termite Resistance of Five Lesser-known Malaysian Hardwoods Used for Roof and Ceiling Construction*

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ABSTRACT

The general laboratory procedure of AWPA E1-97 was used to evaluate the termite resistance of 5 lesser-known species (LKT) of Malaysian hardwoods: Kekatong (*Cynometra* sp.), Kelat (*Eugenia* spp.), Mempening (*Lithocarpus* spp.), Perah (*Elateriospermum tapos*) and Pauh Kijang (*Irvingia malayana*) against the subterranean termite *Coptotermes curvignathus* over 28 days. Kempas (*Koompassia malaccensis*) and Rubberwood (*Hevea brasiliensis*) were included for comparison with these LKT. Employing the AWPA five-point visual rating scale of termite resistance of wood material, Rubberwood and to an extent Mempening, were the least resistant (rating 4-7), Kekatong was virtually immune (rating 9) to the *Coptotermes* species, while Kempas, Kelat, Pauh Kijang and Perah sustained between light-to-moderate attack (rating 7-9). There was a tendency for higher final wood moisture content, higher mass loss or reduced termite mortality to correspond with the lower visual ratings (low termite resistance) generally. In-ground natural durability test results did not correlate with mass loss or visual rating data from the laboratory test.

KEY WORDS: Natural durability, termite resistance, Lesser-utilised timbers, mixed hardwoods, Malaysian hardwoods, *Coptotermes curvignathus*

INTRODUCTION

A fairly high volume of hardwoods in Malaysia is referred to as lesser-known timbers (LKT). Internationally, these timbers are often called lesser-utilised, or lesser-used, species (LUS). However, they are widely used in the building and housing industry (mainly for roof structures) in Malaysia, as a result of the dwindling availability of the commercial heavy and medium hardwoods (ie. those moderate-to-high durability hardwoods possessing good-to-excellent structural properties). Since these Malaysian "LUS" have actually long been utilized locally, their designation as LKT is preferred and carries with it the true implication that the tradesmen have no knowledge of the identity of many of these species (Lim *et al.* 2000). The LKT are also conveniently grouped in the timber trade as mixed light hardwoods, mixed medium hardwoods or red woods on the basis of their gross weight (density) and/or colour of the sawn timbers (Anon. 1984, Ho & Khoo 1992, Lim *et al.* 2000).

This group of Malaysian hardwoods is generally used in protected above-ground applications as building components and furnishings, and the associated biological hazard is less severe than the ground-contact conditions found in wooden poles, timber piles, railway sleepers, fence posts, or the FRIM natural durability test stakes (Mohd. Dahlan & Tam 1987). While combined attack by subterranean termites and decay fungi is frequently observed on wood in ground-contact in tropical forests (Foxworthy 1930), these organisms are often reported to degrade above-ground timbers in isolation from each other. In fact, termite problems without apparent fungal degradation are frequently reported in buildings in Malaysia. The in-ground durability test results of timbers therefore do not always indicate the termite resistance alone of these species, which is the information that is of primary concern to the building industry in roofing construction. Other field or laboratory methods of evaluating wood durability specifically against subterranean termites are required.

The resistance of commercial and potential useful Malaysian timbers to attack by subterranean termites has been evaluated against the Formosan subterranean termite (*Coptotermes formosanus*) in Hawaii, Australian termites (eg. *Coptotermes acinaciformis*, *C. lacteus*, *Nasutitermes exitiosus* and *Mastotermes darwiniensis*) and the Indo-Malaysian *Coptotermes curvignathus* (Thomas 1953, Jackson 1954, Howick & Creffield 1975, Creffield & Tam 1979, Ahmad Said *et al.* 1982, Grace *et al* 1998, Wong *et al.* 1998). As part of an on-going collaborative termite research project between FRIM and the University of Hawaii, the subterranean termite resistance of a series of Malaysian timbers and other tropical woods (primarily the heartwood, since sapwood rarely resists termites or decay fungi) are being evaluated using standard laboratory methodology (AWPA 1997, Grace 1998). This paper discusses the termite resistance of five Malaysian LKT hardwoods, with Kempas and Rubberwood included as reference timbers.

MATERIALS AND METHODS

Wood samples (preferably heartwood) of Kekatong (*Cynometra* spp.), Kelat (*Eugenia* spp.), Mempening (*Lithocarpus* spp. or *Quercus* spp.), Perah (*Elateriospermum tapos*) and Pauh Kijang (*Irvingia malayana*) were obtained from a sawmill, and cut into replicated 20x20x20 mm blocks. The species Kempas (*Koompassia malaccensis*) and the sapwood species Rubberwood (*Hevea brasiliensis*) were also included in the termite test design for comparison, as the termite resistance and natural durability of these hardwoods are already known (Mohd. Dahlan & Tam 1987, Grace *et al.* 1998, Wong *et al.* 1998). Relevant wood characteristics of these Malaysian timbers are described in Table 1.

Table 1. Wood characteristics[1] and properties of selected Lesser-known timbers (LKT), and Kempas and Rubberwood (source: Wong 1982, Anon. 1984, Mohd. Dahlan & Tam 1987)

Tree species	Local name (density class)	Basic density (kg/m^3)	Strength group	Sapwood & Heartwood defined?	Natural durability	Treatability with CCA
Cynometra spp.	Kekatong (HHW, LUS)	880-1155	A	Poor	MD (3.5)	E
Eugenia spp.	Kelat (MHW, LUS)	495-1010	B	Poor	MD (3.5)	VE
Lithocarpus spp. or Quercus spp.	Mempening (MHW, LUS)	575-1010	A-B	Poor	MD (3.5)	D
Irvingia malayana	Pauh Kijang (MHW, LUS)	930-1250	A	Yes	MD (3.5)	E
Elatriospermum tapos	Perah (MHW, LUS)	735-1235	B	Yes	ND (0.5)	E
Koompassia malaccensis	Kempas (MHW)	770-1120	A	Yes	MD (3.5)	VE-E
Hevea brasiliensis	Rubberwood (LHW)	560-640	C	No	ND (0.5)	VE

1. Density class is based on strength and durability (Anon. 1984): HHW=heavy hardwood, MHW=medium hardwood, LHW=light hardwood; Durability rating (Mohd Dahlan & Tam 1987): ND=nondurable (<2 yrs), MD=moderately durable (2-5 yrs); Median durability (years) in parentheses: ND=0.5 years, MD=3.5 years; CCA treatability (Anon. 1991): VE=very easy (>320 lit/m^3), E=easy (240-320 lit/m^3), D=difficult (80-160 lit/m^3); Heartwood-sapwood boundary: well-defined (yes), poorly defined (poor), heartwood absent (no). LKT=lesser-known timbers (LKT).

The wood samples (five replications per species) were exposed to *Coptotermes curvignathus* (Isoptera: Rhinotermitidae) attack for 4 weeks in a no-choice laboratory bioassay (AWPA 1997, Grace *et al.* 1998b). The parameters of termite degradation measured are: (i) visual ratings of test blocks based on the 5-point scale of 10 (sound, surface nibbles permitted), 9 (light attack), 7 (moderate attack with bore holes), 4 (heavy attack), and 0 (failure); (ii) evaluation of wood consumption (absolute mass loss and % mass loss); (iii) evaluation of termite mortality, and (iv) final moisture content of degraded wood.

The subterranean termite *C. curvignathus* was trapped in Rubberwood baitwood bundles placed inside a perforated aluminum container for at least two weeks, at FRIM test site using a simple procedure (Kee 1999). Termites colonised the baitwood by entering the perforations at the base of the closed container. The termites were harvested from baitwood in the laboratory a day after removal from the field, and placed into 375-ml screw-capped jam jars previously filled with washed river sand (150 g) and 30 ml distilled water, with one wood test block centrally placed on the sand in each jar. Each jar assembly contained 400 termites [360 workers and 40 soldiers, to approximate natural *Coptotermes* caste proportions (AWPA 1997)]. Control jars (containing single wood blocks of each species but without termites) were also set up to monitor the test assembly. Jars were incubated in the dark at 27°C for 28 days, and the blocks were then evaluated for termite degradation.

Data were computed for cell means and standard errors. Simple regression analysis to compute the square-root of the coefficient of determinations (R-value) was run on a limited paired sample size of 7 tree species (n=7) to provide indications of probable trends between various parameters of termite resistance in wood. These test statistics were run at the 5% probability level. The median service life of wood species associated with their in-ground durability classes (Mohd. Dahlan & Tam 1987) was regressed using these parameters.

RESULTS AND DISCUSSION

The final moisture contents of the test samples, mass losses, AWPA visual ratings and termite mortality are represented in Table 2 after the 4-week laboratory test. Judging by the visual rating scale, Mempening was the least and Kekatong the most termite-resistant timber among the LKT, with visual ratings of 5.8 and 9.0, respectively. The termite resistance of Perah heartwood trailed closely behind Kekatong, with a rating of 8.6. Pauh Kijang heartwood was moderately resistant with a rating of 7.4, similar to Kempas (Table 2). There is a tendency for the moderate-to-high termite resistant timbers to also record high termite mortality at the end of the laboratory test, as shown in Kekatong (100%), Kelat (100%) and Pauh Kijang (98%) degraded by *Coptotermes curvignathus* (Table 2), but with the exception of Perah (46%). Aqueous or volatile extractives of Kekatong, Kelat and Pauh Kijang may have been highly toxic to *C. curvignathus*. This does not appear to be the case with Kempas, Rubberwood and Perah, judging by the lower termite mortality (Table 2).

As expected, the sapwood species Rubberwood was the most termite-susceptible species, with the blocks sustaining heavy damage (mean visual rating of 4), but not totally or virtually destroyed (mean rating, 1.6) as when these species were previously subjected to the Formosan subterranean termite in Hawaii (Grace *et al.* 1998). This suggests that the

Formosan subterranean termite may display slightly more aggressive natural feeding behaviour than *Coptotermes curvignathus*. The termite susceptibility of Rubberwood was accompanied by moderately low mortality of *Coptotermes curvignathus* (33%, Table 2) and *C. formosarnus* (16.6%, Grace *et al.* 1998), which is also true of other susceptible wood species previously examined [eg. *Albizia falcataria*, *Acacia mangium*, *Pinus caribaea*, *Pinus sylvestris*, *Pseudotsuga menziesii* or *Araucaria cunninghamii* (Grace *et al.* 1996, Grace *et al.* 1998)]. Again, the lower mortality noted with *C. formosanus* in comparison to *C. curvignathus* may indicate relatively more aggressive feeding behaviour of the former termite species.

Table 2. Results of laboratory evaluations of the resistance of selected Malaysian hardwoods exposed to 400 subterranean termites of *Coptotermes curvignathus*

Tree Species	Local name	Final wood moisture content (%g/g)	Mean AWPA Visual rating	Mean absolute mass loss (mg)	Mean mass loss (%g/g)	Mean Termite mortality (%)
Cynometra spp.	Kekatong	58.7 (5.3)	9.0	282.1 (17.7)	4.5 (0.4)	100 (0)
Eugenia spp.	Kelat	61.8 (1.8)	8.2	288.8 (19.5)	4.7 (0.4)	100 (0)
Lithocarpus spp. or *Quercus* spp.	Mempening	53.0 (6.5)	5.8	450.4 (98.5)	7.4 (2.0)	74.4 (8.2)
Irvingia malayana	Pauh Kijang	50.8 (0.9)	7.4	377.7 (33.5)	5.5 (0.5)	98.1 (2.0)
Elatriospermum tapos	Perah	60.1 (4.4)	8.6	656.5 (41.8)	9.9 (0.9)	46.2 (2.2)
Koompassia malaccensis	Kempas	55.5 (2.5)	7.4	607.0 (37.2)	9.8 (0.7)	62.6 (9.9)
Hevea brasiliensis	Rubberwood	111.3 (5.3)	4.0	1020.0 (44.5)	22.8 (1.0)	33.0 (6.0)

(   )=standard error of mean; Visual ratings according to the AWPA scale of 10 (sound, surface nibbles permitted), 9 (light attack), 7 (moderate attack), 4 (heavy attack), or 0 (failure). Cell mean based on 5 replications.

The moderate resistance rating and close to 63% termite mortality noted with Kempas (Table 2) was of interest when compared with the previous test of this wood against *C. formosanus* (Grace *et al.* 1998) which showed both higher termite resistance (mean rating, 9.0) and complete termite mortality (100%). This difference between the tests may be due to the relative tolerance of different termite species to extractives in the wood. Kempas was readily damaged by subterranean termites after 4 weeks exposure in-ground and above-ground contact at FRIM (Wong *et al.* 1998, Wong 2000), possibly due to leaching of extractives, dissipation of volatile toxic substances from the wood, or the influence of a variety of different populations/colonies of termite species at the forest test site. Also in a natural field setting termites are able to forage on a variety of wood substrates (Grace *et al.* 1998). In no-choice laboratory tests, where termites have to feed on the single wood species presented to them, an accumulation of wood toxins in the confined environment could lead to high mortality.

Pooling all 7 wood species, the general relationship between any two parameters measured as indicators of termite resistance are shown in Table 3. This correlation analysis is exploratory due in part to the small sample size. Nevertheless, such test statistics should be useful in wood durability testing (Wong *et al.* 1983, Chafe 1989). Creffield (pers. comm. 2000) and others caution that mass loss alone may not always be a reliable indicator of the termite resistance of wood materials, particularly in field tests. In the present laboratory test, percentage mass loss was obviously closely correlated with absolute mass loss (R-value, 0.972, sig. P=0.05). Percentage mass loss was also significantly negatively correlated with AWPA visual rating (R-value, -0.796), implying that the relative mass losses of woods from a wide range of durability in this case provided good indicators of termite resistance. In one laboratory study (Supriana & Howse 1982) involving classification of termite resistance (against *C. curvignathus* or the drywood termite *Cryptotermes cynocephallus*) of 28 tropical woods, a cluster analysis was used to group absolute mass loss ranges into four resistance classes. It was noted that among the 4 classes, the range of termite feeding (mass loss ranges) differed between *Coptotermes curvignathus* and the less aggressive *Cryptotermes cynocephallus* (Supriana & Howse 1982).

Table 3. Preliminary simple correlation coefficients between the parameters of termite degradation of 7 wood species

FACTORS	FRIM Natural durability class	Termite mortality	Final moisture content	AWPA visual rating	Absolute mass loss
Final moisture content %		-0.650			
AWPA visual rating	0	0.578	-0.712		
Absolute mass loss	-0.453	-0.95 *	0.811 *	-0.719	
% mass loss	-0.464	-0.868 *	0.917 *	-0.796 *	0.972 *

* Correlation coefficients (R-value) significant (P=0.05); n=7; Median of the service-life for each natural durability class (Table 1) was used in the correlation- ND (median: 0.5 years), MD (median: 3.5 years).

The relationship between termite mortality and wood consumption (mass loss) (R-value, -0.95 or –0.868), supported the observation that low termite mortality is generally associated with termite-susceptible wood species in laboratory assessments.

Different wood species have different levels of liquid permeability, due to their different anatomical structures. It is also well known that wood degraded by fungi has higher water permeability than sound wood (Tam & Thornton 1978, Wong & Pearce 1997). The likelihood of wood degraded by termites showing the same relationship was demonstrated in the present study (Table 3), although such a relationship was not observed in a termite field test (Wong *et al.* 1998). The significant positive correlation between final wood moisture content and mass loss (R-value, 0.811 or 0.917) suggests that termites (like fungi) incorporate respiratory water into the wood and may actively transfer water to their feeding substrate (compared with the relatively lower final moisture contents of the control blocks).

The lack of meaningful correlation between mass loss or visual rating of termite attack and the FRIM in-ground natural durability class (median service life) of these woods was not surprising, reinforcing that these are two very different situations for biological degradation. Visual ratings are often considered to be more reliable indicators of termite resistance in field studies than mass loss data (J.W. Creffield pers. comm. 2000), but in our laboratory studies neither measure was correlated with the durability class (median service life) established in the in-ground field studies (Table 3). Therefore, we conclude that laboratory termite tests are more useful for predicting durability in above-ground environments; and are not reliable indicators of wood durability in contact with tropical soils.

Malaysian hardwoods in the LKT group are commonly utilised in building construction for roof structures (Ho 1985), offsetting the declining supplies of traditional structural commercial hardwoods. Although requirements exist for treatment of these woods with preservatives for termite and decay control (Anon. 1991), in reality many roof materials are poorly treated (Wong *et al.* 2000) or even installed untreated. Knowledge of the subterranean termite resistance (as well as the decay resistance) of these diverse hardwood species (Ho & Khoo 1994, Lim *et al.* 2000, Wong *et al.* 2001), will help to provide an informed choice of suitable timbers in situations of risk from subterranean termites.

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REFERENCES

Ahmad Said, S., Rosli, M. & Abd. Rahim, A.S. 1982. The effectiveness of three preservatives and the relative resistance of ten Malaysian hardwoods against the subterranean termite *Coptotermes curvignathus* (Holm.). *Pertanika* 5: 219-233.

Anonymous 1984. *The Malaysian Grading Rules for sawn hardwood timber.* 2nd Ed., Malaysian Timber Industry Board, 109 pp.

Anonymous 1991. Malaysian Standard MS 360:1991. Specification for treatment of timber with copper/chrome/arsenic preservatives. *Standards and Industrial Research Institute of Malaysia (SIRIM).*

Anonymous 1997. American Wood-Preservers' Association. Standard method for laboratory evaluation to determine resistance to subterranean termites. E1-97. *AWPA Book of Standards.*

Chafe, S.C. 1989. Observations on the relationship between wood durability and density. *Journal of The Institute of Wood Science* 11: 182-185.

Creffield, J.W. 2000. Personal communication during the 31st Annual Meeting of The International Research Group on Wood Preservation, held on 14-19 May 2000, Kona, Hawaii USA.

Creffield, J.W. & Tam, M.K. 1979. Laboratory assessments of the efficacy of CCA and PCP-treated *Dyera costulata* (jelutong) against two species of Australian termites. *Malaysian Forester* 42:230-239.

Foxworthy, F.W. 1930. Durability of Malayan timbers. I. Untreated timbers. *Malayan Forest Records* No.8, pp. 1-36.

Grace, J.K. 1998. Resistance of pine treated with chromated copper arsenate to the Formosan subterranean termite. *Forest Products Journal* 48: 79-82.

Grace, J.K., Ewart, D.M. & Tome, C.H.M. 1996. Termite resiatance of wood species grown in Hawaii. *Forest Products Journal* 46: 57-60.

Grace, J.K., Wong, A.H.H. & Tome, C.H.M. 1998. Termite resistance of Malaysian and exotic woods with plantation potential: laboratory evaluation. *The International Research Group on Wood Preservation, Document* No: IRG/WP 98-10280.

Ho, K.S. 1985. Malaysian timbers for purlins, floor joists and ceiling joists. *Malaysian Forest Service Timber Trade Leaflet* No.96, Published by Malaysian Timber Industry Board.

Ho, K.S. & Khoo, K.C. 1994. Utilization of commercially less-accepted species and wood residues (Country report from Malaysia). *Proceedings of IUFRO Division 5 / ITTO / FRIM International Workshop on Improved Utilization of Timber Resources in Southeast Asia*, 7-11 December 1992, Kuala Lumpur, Malaysia. Published by Forest Research Institute Malaysia, pp. 290-320.

Howick, C.D. & Creffield, J.W. 1975. The development of standard laboratory bioassay technique with *Mastotermes darwiniensis* Froggatt (Isoptera: Mastotermitidae). *Zeitschrift fur angewandte Entomologie* 78: 126-138.

Jackson, W.F. 1954. Durability of Malayan timbers. *Malayan Forest Records* No.8, Forest Department, Kuala Lumpur.

Kee, S.C. 1999. Evaluations of some insecticides as preservatives for rubberwood. *Bachelor of Science (Forestry) Thesis*, Universiti Putra Malaysia (unpublished).

Lim, S.C., Shamsudin, M. & Gan, K.S. 2000. Availability and utilization of lesser-known timbers. Paper presented at *the National Seminar on Alternatives to Rubberwood, Conference on Forestry and Forest Products Research (CFFPR) 2000 Series*, 26 September 2000, Forest Research Institute Malaysia, Kepong, 17 pp.

Mohd. Dahlan, J. & Tam, M.K. 1987. Natural durability of Malaysian timbers. *Timber Trade Leaflet* No. 28, published by Malaysian Timber Industry Board & Forest Research Institute Malaysia, 12 pp.

Supriana, N. & Howse, P.E. 1982. Termite resistance of twenty-eight Indonesian timbers. *The International Research Group on Wood Preservation, Document* No: IRG/WP/1150.

Tam, M.K. & Thornton, J.D. 1978. Mass loss and moisture content changes in CCA and PCP-treated *Dyera costulata* (jelutong) following inoculation with the brown rot fungus *Gloeophyllum trabeum. Malaysian Forester* 41: 346-357.

Thomas, A.V. 1953. Report of laboratory tests to determine the resistance to termite attack of certain Malayan commercial timbers. *Malayan Forester* 16: 45-49.

Wong, A.H.H. 2000. Resistance of two commercial cement-bonded rubberwood particle composites to decay and termites. *International Research Group on Wood Preservation, Document* No: IRG/WP 00-10338.

Wong, A.H.H. & Pearce, R.B. 1997. Soft rot decay and variable preservative retentions in copper-chrome-arsenic treated Malaysian hardwood utility poles. *Journal of Tropical Forest Products* 2: 216-226.

Wong, A.H.H., Grace, J.K. & Kirton, L.G. 1998. Termite resistance of Malaysian and exotic woods with plantation potential: field evaluation. *The International Research Group on Wood Preservation, Document* No: IRG/WP 98-10289.

Wong, A.H.H., Kee, S.C., Lim, S.C. & Grace, J.K. 2001. Subterranean termite resistance of some commercial and lesser-utilised Malaysian hardwoods used for roof structures of houses. Paper presented at *Malaysian Pest Control Convention & Exhibition 2001*, 11-13 April 2001, Bayview Beach Resort, Penang, Malaysia, 10 pp.

Wong, A.H.H., Lim, S.C., Henriksen, K.H., Choo, K.T., Mohd. Dahlan, J. & Salamah, S. 2000. High incidence of inadequate treatment of Peninsular Malaysian mixed hardwoods with copper-chrome-arsenic preservatives for structural use. Paper presented at *Division 5 Research Group 5.03 (Wood Protection) Session, 21st International Union of Forestry Research Organizations (IUFRO)*, 7-12 August 2000, Kuala Lumpur, Malaysia.

Wong, A.H.H., Wilkes, J. & Heather, W.A. 1983. Influence of wood density and extractives content on decay resistance of the heartwood of *Eucalyptus delegatensis* R.T. Baker. *Journal of the Institute of Wood Science* 9: 261-263.

Wong, T.M. 1982. Dictionary of Malaysian timbers. *Malayan Forest Records* No.30, Published by Forest Department, Peninsular Malaysia, 259 pp.