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# DURABILITY OF MANGROVE TIMBER AGAINST TERMITES

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## INTRODUCTION

Malaysia is one of the countries in Southeast Asia with the largest mangrove area covering approximately 63,000 ha (61% in Sabah, 22% in Sarawak and 17% in Peninsular Malaysia) (Hamdan et al. 2018). *Rhizophora* sp., locally known as bakau, is a wood species of the mangrove family (Rhizophoraceae). This family consists of three species: *R. mucronata, R. stylosa* and *R. apiculata* and two hybrids: *R.* x *lamarckii and R.* x *annamalai*. It is a tree that can adapt to a wide range of downstream river estuaries. With the growth rate of 1m/yr, it can reach up to 30–40 m in height. Besides being used as fuelwood, charcoal, dyes, structural components and traditional medicine, it is also known to play a vital role in shoreline protection, enhancement of water quality in nearshore environments (including coral reefs) and in supporting estuarine and marine food chains (Duke 2006).

**Figure 1** *Rhizophora* sp. trees at Matang Mangrove Forest Reserve, Kuala Sepetang, Perak (left) and *Rhizophora* sp. sawn timber (right)

Previous study (Patra et al. 2011, Saho et al. 2012) reported that mangrove tree is a rich source of several bioactive compounds: sterioids, triterpenes, saponins, flavonoids, alkaloids and tannins, where all of these substances are reported to be toxic to some wood pesticide agents such as termites, fungi, mosquitoes etc. This makes the wood to be categorized as moderately durable class in service. However, it has not been tested with an aggressive termite species in Malaysian conditions. So, this study was initiated to evaluate the resistance of *Rhizophora* sp. against *C. curvignathus* in laboratory and field conditions.

**Figure 2** Product from *Rhizophora* sp. timber

## MATERIALS AND METHODS

*No-Choice Test*

Three *Rhizophora* sp. trees were collected from Matang Mangrove Forest Reserve, Kuala Sepetang, Perak. Wood specimen measuring 25 mm × 25 mm × 6 mm were cut from the heartwood of the log. The samples were subjected to termite bioassays according to the no-choice test procedure of FRIM in house method (IHM/WEL/4) (2014). Subterranean termites, *Coptotermes curvignathus* Holmgren (Isoptera: Rhinotermitidae), were collected from active field colonies that attacked rubberwood logs placed around the Forest Research Institute Malaysia (FRIM) campus (Field 51). The wooden logs were cut and brought back to the laboratory to isolate termites according to the caste (soldiers and workers).

Screw-top bottles of 8 cm in diameter by 15 cm height were filled with 200 g of sterilized sand and 30 ml distilled water (Figure 3). The bottles were left overnight to equilibrate to laboratory conditions before test initiation. One block of specimen was placed at the bottom surface of the damp sand and 400 termites (360 workers and 40 soldiers) were added to each bottle. All bottles were stored in an incubator maintained at 22 $\pm$ 2 $^{o}$C and 65 $\pm$ 5 % relative humidity for 28 days. Within this period, if it was found that all termites appeared dead, the bottle would be taken out and the number of days until 100 % mortality would be recorded. At the end of the

fourth week the blocks were removed, cleaned with brush, dried overnight and reweighed. The remaining live termites were weighed and recorded for each of the bottles. As detailed in the standard, the condition of the test blocks was rated visually using a 0–10 scale where 10 is rated as sound and 0 represents total failure (Table 1).

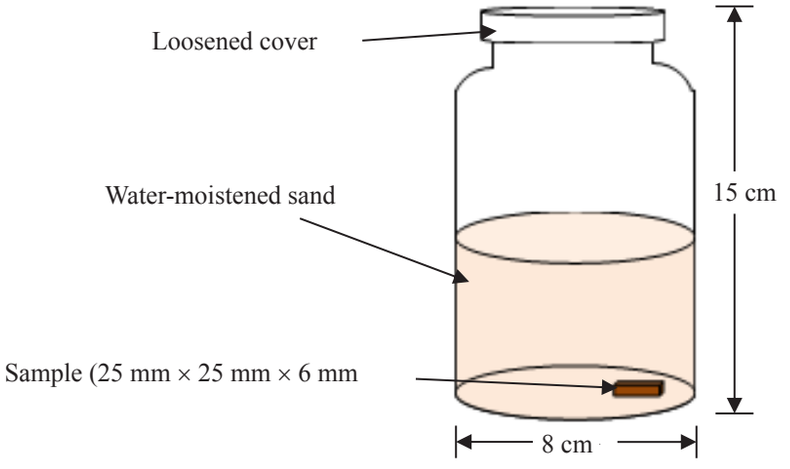


**Figure 3** The arrangement of wood specimen according to FRIM in house method (IHM/WEL/4) (2014)

**Table 1** Visual rating system based on IHM/WEL/4 (2014)

| Rating | Description |
|---|---|
| 10 | Sound |
| 9.5 | Trace, surface nibbles permitted |
| 9 | Slight attack up to 3% of cross sectional area affected |
| 8 | Moderate attack, 3–10% of cross sectional area affected |
| 7 | Moderate/severe attack, penetration, 10–35% of cross sectional area affected |
| 6 | Severe attack, 30–50% of cross sectional area affected |
| 4 | Very severe attack, 50–75% of cross sectional area affected |
| 0 | Failure |

*Above-ground test*

Wood specimen blocks measuring 100 mm × 40 mm × 20 mm were cut from the outer heartwood from the basal, middle and top portion of three trees and subjected to termite above-ground test according to FRIM in-house standard method (IHM/WEL/1 2004).

Two drums were installed near to the area that at least one species of subterranean termites exist in the FRIM campus area. At the bottom of the drum, a layer of highly susceptible timber substrates, rubberwood (*Hevea brassiliensis*) was tightly packed on their ends. Then, one square section of a galvanised welded mesh (25 mm square opening), were put on the top of the timber substrates. The test specimens sandwiched with rubberwood were placed on the top of the galvanised welded mesh. The test specimens were randomly arranged to avoid contact with each other (Figure 4). All the samples were left undisturbed for sixteen weeks.

At the end of the sixteen week, the test samples were removed, cleaned, dried overnight and reweighed. As detailed in the standard, the condition of the test samples was rated visually using the rating system as shown in Table 2.

**Table 2** Visual rating system (IHM/WEL/1 2004)

| Rating | Description |
|---|---|
| 0 | Sound |
| 1 | Trace attack |
| 2 | Slight attack |
| 3 | Moderate attacks, penetration |
| 4 | Severe attack |
| 5 | Failure by termite attack |

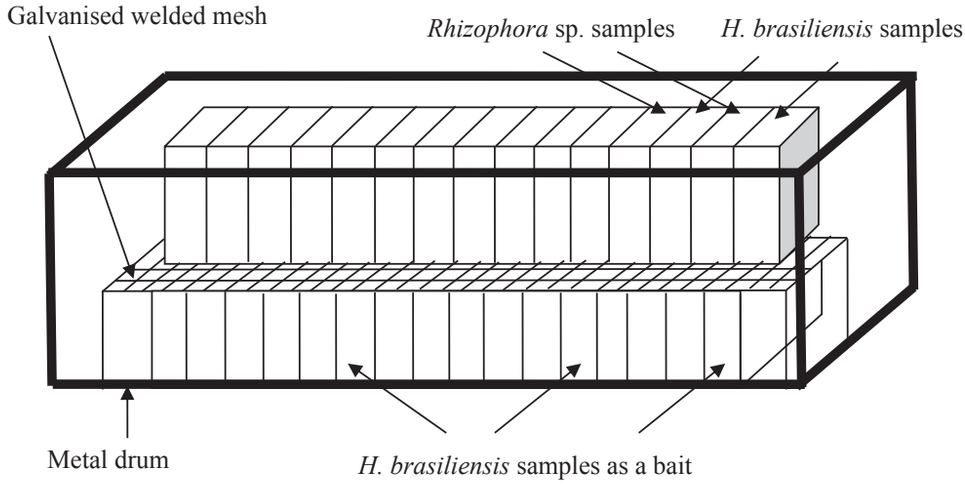


**Figure 4** The setup of above-ground test

### *Statistical analysis*

An analysis of variance (ANOVA) was carried out using the MINITAB 15 software to test the between- and within-tree differences in termite resistance.

## RESULTS AND DISCUSSION

### *No-choice test*

A comparison of the resistance levels of *Rhizophora* sp. against *C. curvignathus* in the no-choice feeding test is summarized in Table 2.

Generally, *Rhizophora* sp. is more resistance or least preferred by *C. curvignathus* than *H. brasiliensis* as compared by weight loss of samples and mortality of termites used. An average of only 1.84 % of weight loss occurs on *Rhizophora* sp. while higher weight loss (11.99 %) occurs on *H. brasiliensis* samples. Visual observations supported the results of mass losses (Figure 5). The mean visual rating was 9.90 (between trace, surface nibbles and sound) for *Rhizophora* sp. and 6.80 (severe to moderate attack) for *H. brasiliensis*. The results indicate that *Rhizophora* sp. is resistant to *C. curvignathus* and that *H. brasiliensis* is non-resistant. However, it should be noted that these results were obtained in the laboratory using small numbers of termites in situations where they had no other wood sample to consume. On the other hand, the higher resistant of *Rhizophora* sp. could be due to the high proanthocyanidin (condensed tannin) and flavonoid contents of its wood which are known to deter consumption by insects and other herbivores (Abdul Khalil et al. 2009).

Table 3 also show that a complete (100 %) mortality was experienced with *Rhizophora* sp. wood species and there were about 28.05% of surviving termites in bottles containing *H. brasiliensis* samples. All of the termites feeding on *Rhizophora* sp. died within 16 days.

**Table 3** Average weight loss, termite mortality and visual rating in bio-assay of *Rhizophora* sp. against subterranean termites

| Species | Weight loss (%) | Visual rating | Mortality (%) |
|---|---|---|---|
| *Rhizophora* sp. | 1.84 (0.46)[b] | 9.90 (1.14)[a] | 100 (Complete)[a] |
| *H. brasiliensis* | 11.99 (2.76)[a] | 6.80 (0.84)[b] | 71.95 (Heavy)[b] |

[1]Each value represents the means of 10 replicates. Values in parentheses are standard deviations.
[2]Termite attack visual rating scale: 0, failure; 4, very severe attack, 50–75 % of cross sectional area affected; 6, severe attack, 30–50 % of cross sectional area affected, 7, Moderate/severe attack, penetration, 10–35 % of cross sectional area affected, 8, moderate attack, 3–10 % of cross sectional area affected; 9, slight attack up to 3 % of cross sectional area affected; 9.5, trace, surface nibbles permitted and 10, sound.
Mean values for percentage of weight loss (%) by the same letter (vertical) are not significantly ($P<0.05$) different based on ANOVA.


**Figure 5** The *Rhizophora* sp. (left) and *H. brasiliensis* (right) samples after 28 days' exposure to *C. curvignathus*

### *Above-ground test*

The natural resistance of *Rhizophora* sp. was also evaluated through above-ground field test. The test was carried out in FRIM Research Substation, Mata Ayer, Perlis at a relatively low temperature (22–28 °C) in order to obtain a high termite activity. Average weight loss and visual rating of wood samples after above-ground test are given in Table 3. All *H. brasiliensis* samples were destroyed or severely attacked by *C. curvignathus* while only 6 out of 10 replicates of *Rhizophora* sp. were attacked. The weight loss for *Rhizophora* sp. was between 0.62 % to 7.49 % with an average of 3.90 %. The destruction of the *H. brasiliensis* samples [25.46 to 66.43 % (average = 43.14 %)] and the bait-wood, demonstrate that the test samples were subjected to a high level of termite activity during the field trial. The visual rating of matured *Rhizophora* sp. at the end of the exposure period was 1.0 which mean only minor attack was detected. There was a significant different based on the visual rating for all specimens tested (Figure 6). Based on the result obtained, the *Rhizophora* sp. was categorized under durable to moderate durable class.

Other factors such as moisture content, extractive content and wood density also play an important role in determining durability of the heartwood though not investigated in the present study. The lower mean percentage of weight loss in the lower part of the trees due to termite agrees with previous observation of other wood species. The higher percentage of weight loss at the top position could also due to the higher juvenile wood percentage and lower extractive content (Taylor et al. 2002).

**Table 4** Average weight loss and visual rating of wood samples after above-ground field test

| Species | Weight loss (%) | Visual rating |
|---|---|---|
| *Rhizophora* sp. | 3.90 (2.31)[b] | 1.0 (0.00)[b] |
| *H. brasiliensis* | 11.99 (2.76)[a] | 4.8 (0.45)[a] |

[1]Each value represents the means of 10 replicates. Values in parentheses are standard deviations.
[2]Termite attack rating scale: 0, sound; 1, trace attack, surface nibbles permitted; 2, slight attack, up to 10% of cross sectional area affected; 3, moderate/severe attacks, penetration, 11-40% of cross sectional area affected; 4, heavy attack, 41-70% of cross sectional area affected and 5, failure by termite attack.
[3]Mean values of percentage of weight loss (%) of the same letter (vertical) are not significantly ($P<0.05$) different.

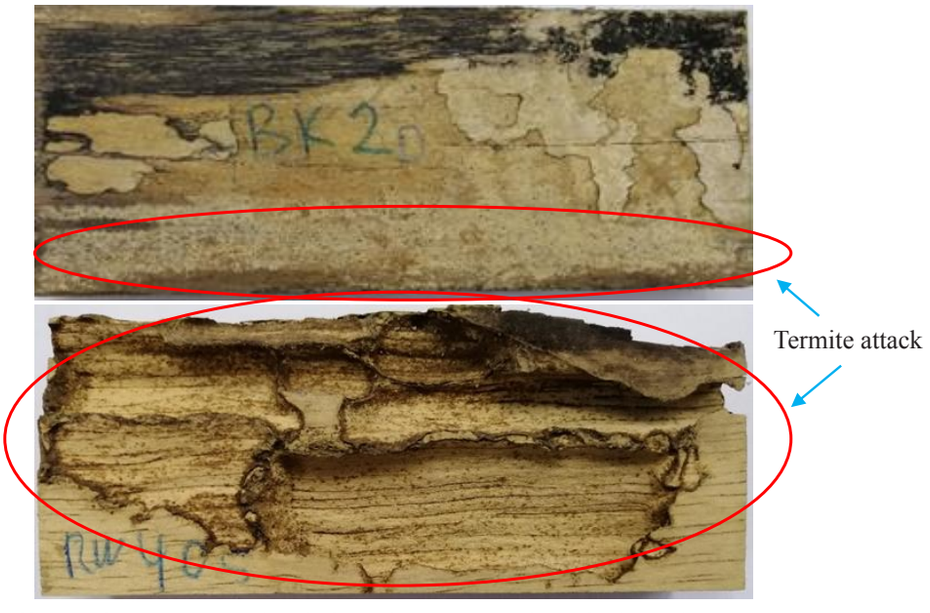


**Figure 6** Effects of *C. curvignathus* infestation on samples of *Rhizophora* sp. (top) and *H. brasiliensis* (bottom) after 16 weeks of exposure in above-ground tests

## CONCLUSION

Based on weight loss after 4 weeks of no-choice test and sixteen weeks of above-ground field test exposure of *Rhizophora* sp. samples, *Rhizophora* sp. was found resistant against termite attack in laboratory tests and further confirmed with field tests showing 3 times lower weight loss (3.90%) and almost five times better in visual rating (1.0) than *H. brasiliensis* (11.99% and 4.8, respectively). Thus *Rhizophora* sp. can be rated as durable. However, for more effective use in the long term, *Rhizophora* sp. requires some form of chemical treatment.

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Subterranean termites are the biggest contributor to wood and wood products damage billions of dollars each year, and their food is wood (cellulose). Due to the lack of supply of wood from classes that have natural durability, use has been focused on wood species from other classes, i.e. from moderately durable or non-durable with treatment. However, to date, few termite infestation studies have been conducted from that class. This study evaluated the natural resistance against termites of mangrove species. Tests are performed in the laboratory as well as in the field. The results showed that the mangroves were resistant to the attack of *Coptotermes curvignathus*.



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