

# DECAY RESISTANCE OF 84 INDONESIAN WOOD SPECIES AGAINST FUNGI

S Suprapti

Forest Products Research and Development Center, Jalan Gunung Batu 5, Bogor 16610, Indonesia. E-mail: [sihatisuprapti@yahoo.com](mailto:sihatisuprapti@yahoo.com)

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**SUPRAPTI S. 2010. Decay resistance of 84 Indonesian wood species against fungi.** Eighty-four species of wood from Aceh, Jambi, Riau, Sulawesi, Moluccas, Kalimantan and Java, which cover 36 families and 67 genera, were evaluated for their resistance against brown rot (*Dacryopinax spathularia*) and white rot (*Pycnoporus sanguineus* and *Schizophyllum commune*) attacks using Kolle-flask method (DIN 52176-modified standard). Results showed that the attack of white rot fungi were generally more severe than that of brown rot fungi. It was found that 30 wood species were categorised as resistant (class II), 20 species as moderately resistant (class III), 32 species as non-resistant (class IV) and 2 species as perishable (class V).

Keywords: Brown rot, white rot, *Dacryopinax spathularia*, *Pycnoporus sanguineus*, *Schizophyllum commune*

**SUPRAPTI S. 2010. Kerintangan 84 spesies kayu Indonesia menentang kulat.** Sebanyak 84 spesies kayu yang tergolong dalam 36 famili dan 67 genus dan berasal dari Aceh, Jambi, Riau, Sulawesi, Kepulauan Maluku, Kalimantan and Jawa dinilai dari segi ketahanan menentang serangan reput perang (*Dacryopinax spathularia*) dan reput putih (*Pycnoporus sanguineus* serta *Schizophyllum commune*). Kaedah yang digunakan ialah kaedah kelalang Kolle (standard DIN 52176 yang diubah suai). Pada umumnya keputusan menunjukkan bahawa serangan kulat reput putih lebih teruk berbanding dengan kulat reput perang. Sebanyak 30 spesies kayu dikategorikan sebagai tahan (kelas II), 20 sebagai sederhana (kelas III), 32 sebagai tidak tahan (kelas IV) dan dua sebagai mudah rosak (kelas V).

## INTRODUCTION

The endurance of a wood species to attacks by degrading organisms such as termite, powderpost beetle, marine borer and fungi will determine its natural durability (Martawijaya 1996). Factors that influence wood resistance include site, growth rate, age of tree, portion of wood (heartwood and sapwood), extractive contents in wood and the environment the wood is being exposed to. Wood for building material is assessed by its durability and a low durability would mean a short service life. Therefore, natural durability against decaying organism is an important property in wood. Natural durability of Indonesian woods is divided into five classes, i.e. I to V (Seng 1990). Class I is regarded as durable or most resistant wood and in decreasing order, class V, the lowest resistant or the most perishable wood.

Several researches concerning wood decay resistance against fungi have been reported, e.g. Martawijaya (1975), Amemiya and Matsuoka

(1979), Wong (1988), Salmiah and Amburgey (1992), and Sukartana and Highley (1997). However, not much emphasis is given to the classification of natural resistance of Indonesian woods against fungal attack. Therefore, in this study, *in vitro* evaluations on the resistance of wood to fungal decay were made based on mass loss value of post-decay wood blocks. Several species of wood were subjected to fungal decay by exposing them to brown rot (*Dacryopinax spathularia*) and white rot (*Pycnoporus sanguineus* and *Schizophyllum commune*) fungi. These three fungi were categorised as the most virulent fungi capable of attacking almost all wood species (Djarwanto *et al.* 2007). This paper is intended to present the decay resistance of 84 Indonesian wood species against *D. spathularia*, *P. sanguineus*, and *S. commune* in a laboratory experiment. From this study is also expected that laboratory experiment will shorten the time needed to determine the natural durability of wood.

## MATERIALS AND METHODS

*Dacryopinax spathularia* HHBI-145 (brown rot fungus) and *Pycnoporus sanguineus* HHBI-8149 and *Schizophyllum commune* HHBI-204 (white rot fungi) used in this study were obtained from the forest products fungus collection in Bogor, Indonesia. For this experiment, culture media used was made using 3% malt extract and 2% agar in distilled water. Wood samples containing heartwood were obtained from 84 wood species from Aceh (13 species), Jambi (5 species), Riau (1 species), East Kalimantan (11 species), South Kalimantan (1 species), Central Kalimantan (5 species), Moluccas (1 species), South Sulawesi (1 species), Central Sulawesi (2 species), East Java (1 species) and West Java (44 species). There were 85 wood specimens. Each specimen consisted of 18 samples, in the form of small blocks measuring of 2.5 (width) × 1.5 (thick) × 5 cm (length in the direction of wood grain). Samples were treated by three fungal species with six replicates for each specimen.

The decay test was conducted based on the Kolle-flask method by DIN 52176 standard which has been modified by Martawijaya (1975), and Djarwanto and Suprapti (2004). Culture media used was made using 3% malt extract and 2% agar in distilled water and poured into Kolle-flasks (80 ml for each flask). The flasks were then plugged with cotton and then sterilised in an autoclave at a temperature of 121 °C and pressure of 1.5 atm for 30 min and subsequently allowed to cool. After cooling, the sterilised medium in each flask was inoculated by pure culture of tested fungi. The inoculated medium was then incubated until the mycelium growth on the surface of the medium spread and was distributed evenly and became slightly thick.

Before the tests, all blocks were numbered, oven dried at 105 °C for 24 hours and weighed

repeatedly until a constant weight was achieved. Test blocks were then put in pairs on each fungi culture aseptically and incubated for 12 weeks. To determine decay, the percentage of weight loss of wood sample was calculated under oven-dry weight condition before and after incubation and thereafter. To classify wood decay resistance, average weight loss of wood samples were measured and determined (Martawijaya 1975, Djarwanto & Suprapti 2004), and the expectancy of service life for each class was ascertained according to Seng (1990) as shown in Table 1.

## RESULTS AND DISCUSSION

Deterioration of wood could be indicated by its weight loss due to fungal attack. The average weight loss of wood samples varied depending on fungal and wood species (Table 2). Wood which suffered either by brown or by white rot has the common feature of loss in weight and strength (Coggins 1980). Depolymerisation of cellulose by brown rot fungi causes the collapse of wood strength (Highley 1991).

Due to shortening and degradation of wood fibres, *Polyporus hispidus* was able to decrease 20% of impact bending strength (toughness) of ash wood after only two weeks of exposure (Cartwright & Findlay 1943). This was caused mainly by depletion and alteration of the cellulose and its associated pentosans. Martawijaya (1996) stated that impact bending strength of sengon wood (*Paraserianthes falcataria*) decreased 80% 24 weeks after being inoculated with *S. commune*. Generally, weight loss of wood caused by fungal attack depends on wood species and also species and strain of fungi (Takahashi & Nishimoto 1967, Pildain *et al.* 2005).

To justify the resistance of a wood species, it should be stated clearly from which part and

**Table 1** Classification of wood resistance based on weight loss caused by fungi

Average weight loss (%)	Decay resistance	Resistance class	Expectancy of service life (years)
None or negligible	Very resistant	I	≥ 8
< 5	Resistant	II	6–7
5–10	Moderately resistant	III	4–5
10–30	Non-resistant	IV	2–3
> 30	Perishable	V	< 2

**Table 2** Percentage of weight loss and resistance class of the samples after exposure to fungi

Class	Origin	Weight loss percentage and resistance			Resistance class	
		<i>D. spathularia</i>	<i>P. sanguineus</i>	<i>S. commune</i>	This study *	Seng **
Class II (Resistant)						
<i>Azadirachta indica</i>	East Java	0.98 ± 0.49 II	0.88 ± 0.41 II	1.59 ± 0.52 II	II	III
<i>Lindera polyantha</i>	West Java	1.18 ± 1.05 II	1.73 ± 0.62 II	0.81 ± 0.65 II	II	IV/V
<i>Garcinia nervosa</i>	Aceh	1.23 ± 0.45 II	1.29 ± 0.44 II	1.24 ± 0.39 II	II	IV
<i>Dialium indum</i>	Aceh	1.28 ± 0.40 II	1.27 ± 0.17 II	1.50 ± 0.27 II	II	I
<i>Tristaniopsis whitheana</i>	Central Kalimantan	0.70 ± 0.20 II	1.05 ± 0.59 II	2.48 ± 1.01 II	II	I
<i>Shorea laevifolia</i>	East Kalimantan	1.34 ± 0.17 II	1.14 ± 0.11 II	1.77 ± 0.44 II	II	I–II(III)
<i>S. platyclados</i>	East Kalimantan	1.52 ± 0.09 II	1.01 ± 0.31 II	1.82 ± 0.47 II	II	III–IV
<i>Acacia mangium</i>	West Java	0.59 ± 0.11 II	0.91 ± 0.61 II	3.22 ± 0.92 II	II	III
<i>Turpinia sphaerocarpha</i>	West Java	1.24 ± 0.94 II	1.58 ± 0.86 II	2.37 ± 0.50 II	II	V
<i>Manilkara kanosiensis</i>	Mollucas/Maluku	1.80 ± 0.51 II	1.63 ± 0.51 II	1.96 ± 0.35 II	II	I
<i>Vitex cofassus</i>	Central Sulawesi	0.93 ± 0.08 II	1.38 ± 0.15 II	3.27 ± 1.08 II	II	II–III
<i>Kokoona reflexa</i>	Aceh	1.13 ± 0.30 II	1.80 ± 0.68 II	3.02 ± 0.89 II	II	-
<i>Dehaasia firma</i>	Central Kalimantan	2.39 ± 0.49 II	2.23 ± 0.62 II	2.04 ± 0.62 II	II	II
<i>Amoora rubiginosa</i>	Aceh	1.96 ± 0.64 II	1.16 ± 0.25 II	4.32 ± 1.13 II	II	II–III
<i>Manilkara merrilliana</i>	South Sulawesi	2.83 ± 0.27 II	2.61 ± 0.10 II	2.80 ± 0.12 II	II	I
<i>Teysmaniodendron sympliciooides</i>	Central Kalimantan	1.53 ± 0.58 II	0.50 ± 0.14 II	7.12 ± 2.06 III	II (II–III)	II–III
<i>Gironniera subaequalis</i>	West Java	2.60 ± 1.08 II	2.22 ± 1.24 II	4.37 ± 1.82 II	II	IV/V
<i>Pterospermum elongatum</i>	Aceh	6.71 ± 2.11 II	1.93 ± 0.68 II	1.47 ± 0.53 II	II (II–III)	-
<i>Vitex pubescen</i>	West Java	0.75 ± 0.38 II	2.96 ± 0.22 II	6.52 ± 1.94 III	II (II–III)	I
<i>Palaquium gutta</i>	Jambi	1.12 ± 0.35 II	3.67 ± 1.04 II	6.81 ± 1.41 III	II (II–III)	IV
<i>Trigonopleura malayana</i>	Central Kalimantan	3.70 ± 0.13 II	2.41 ± 0.79 II	5.73 ± 2.87 III	II (II–III)	IV
<i>Castanopsis tunggurrut</i>	West Java	0.51 ± 0.33 II	1.58 ± 0.49 II	10.46 ± 1.26 IV	II (II–IV)	II–IV
<i>Litsea odorifera</i>	West Java	0.62 ± 0.34 II	0.57 ± 0.46 II	11.38 ± 1.67 IV	II (II–IV)	III/IV
<i>Acacia aulacocarpa</i>	West Java	1.99 ± 0.81 II	1.67 ± 0.74 II	9.30 ± 2.14 III	II (II–III)	-
<i>Planchonia grandis</i>	East Kalimantan	1.72 ± 0.71 II	8.72 ± 2.24 III	2.76 ± 0.31 II	II (II–III)	II/III
<i>Pinus merkusii</i>	West Java	5.52 ± 1.04 III	4.07 ± 0.99 II	3.88 ± 0.95 II	II (II–III)	IV
<i>Hymenaea courbaril</i>	West Java	1.78 ± 0.85 II	3.38 ± 1.32 II	8.99 ± 2.32 III	II (II–III)	III
<i>Lancium</i> sp.	East Kalimantan	3.32 ± 1.15 II	4.51 ± 1.50 II	6.79 ± 2.18 III	II (II–III)	II
<i>Eucalyptus pellita</i>	Riau	0.98 ± 0.52 II	2.44 ± 0.88 II	11.26 ± 2.24 IV	II (II–IV)	II
<i>Ganophyllum falcatum</i>	West Java	2.24 ± 0.58 II	11.35 ± .24 IV	1.17 ± 0.15 II	II (II–IV)	III

(continued)

**Table 2** (continued)

Class	Origin	Weight loss percentage and resistance			Resistance class	
		<i>D. spathularia</i>	<i>P. sanguineus</i>	<i>S. commune</i>	This study *	Seng **
Class III (moderately resistant)						
<i>Callophyllum grandiflorum</i>	West Java	5.46 ± 1.15 III	3.64 ± 0.83 II	6.11 ± 1.72 III	III (II–III)	III
<i>Acacia crassicarpa</i>	South Kalimantan	1.20 ± 0.37 II	1.00 ± 0.55 II	16.51 ± 3.42 IV	III (II–IV)	-
<i>Agathis borneensis</i>	West Java	4.79 ± 1.29 II	9.58 ± 2.27 III	5.16 ± 0.52 III	III (II–III)	IV
<i>Castanopsis acuminatissima</i>	West Java	1.37 ± 0.39 II	2.46 ± 0.62 II	16.28 ± 1.05 IV	III (II–IV)	III
<i>Altingia excelsa</i>	West Java	1.65 ± 0.17 II	1.58 ± 0.35 II	17.11 ± 3.46 IV	III (II–IV)	II–III
<i>Vitex glabrata</i>	Central Sulawesi	1.12 ± 0.45 II	10.74 ± 1.87 IV	8.84 ± 1.64 III	III (II–IV)	II–III
<i>Pterospermum diversifolium</i>	Jambi	2.51 ± 0.88 II	7.02 ± 1.48 III	12.91 ± 0.98 IV	III (II–IV)	IV
<i>Endospermum diadenum</i>	Aceh	14.13 ± 3.72 IV	2.93 ± 1.08 II	5.44 ± 1.80 III	III (II–IV)	-
<i>Tamarindus indica</i>	West Java	5.80 ± 0.92 III	7.47 ± 1.35 III	10.08 ± 2.43 IV	III (III–IV)	I
<i>Acacia auriculiformis</i>	West Java	2.58 ± 0.75 II	1.79 ± 0.36 II	19.12 ± 2.84 IV	III (II–IV)	III
<i>Parkia javanica</i>	Aceh	10.63 ± 4.18 IV	9.63 ± 0.99 III	3.37 ± 0.97 II	III (II–IV)	-
<i>Neolitsea triplinervia</i>	West Java	3.54 ± 1.36 II	5.58 ± 1.39 III	14.71 ± 3.54 IV	III (II–IV)	III/IV
<i>Diplodiscus</i> sp.	West Java	5.78 ± 0.85 III	7.01 ± 2.02 III	11.14 ± 1.14 IV	III (III–IV)	-
<i>Artocarpus horridus</i>	West Java	4.96 ± 1.46 II	6.73 ± 0.48 III	13.63 ± 2.01 IV	III (II–IV)	-
<i>Paraserianthes falcataria</i>	West Java	11.07 ± 2.22 IV	9.35 ± 1.12 III	5.42 ± 1.11 III	III (III–IV)	IV–V
<i>Mezzettia parviflora</i>	Aceh	9.45 ± 2.60 III	8.99 ± 1.58 III	8.96 ± 1.80 III	III	V
<i>Cananga odorata</i>	Aceh	20.63 ± 3.68 IV	4.51 ± 1.21 II	2.61 ± 0.90 II	III (II–IV)	V
<i>Glochidion philippicum</i>	East Kalimantan	2.03 ± 0.63 II	10.63 ± 1.31 IV	15.23 ± 2.45 IV	III (II–IV)	III
<i>Pouteria duclitan</i>	West Java	6.07 ± 1.76 III	12.83 ± 3.41 IV	9.22 ± 2.06 III	III (III–IV)	-
Class IV (non-resistant)						
<i>Xanthophyllum excelsum</i>	Aceh	11.54 ± 2.59 IV	9.58 ± 1.67 III	8.96 ± 1.80 III	IV (III–IV)	V
<i>Litsea angulata</i>	West Java	8.57 ± 1.48 III	5.91 ± 0.93 III	17.31 ± 1.41 IV	IV (III–IV)	IV
<i>Drypetes</i> sp.	East Kalimantan	2.88 ± 0.98 II	7.79 ± 2.22 III	21.26 ± 7.57 IV	IV (II–IV)	III
<i>Cinnamomum iners</i>	West Java	2.17 ± 0.15 II	8.09 ± 1.79 III	22.93 ± 4.13 IV	IV (II–IV)	IV/V
<i>Ehretia accuminata</i>	West Java	1.33 ± 0.78 II	21.47 ± 5.77 IV	12.04 ± 1.28 IV	IV (II–IV)	III
<i>Gonystylus macrophyllum</i>	Aceh	9.45 ± 2.21 III	14.92 ± 1.11 IV	10.73 ± 1.01 IV	IV (III–V)	V
<i>Blumeodendron kurzii</i>	East Kalimantan	5.00 ± 1.84 III	11.47 ± 2.55 IV	19.68 ± 4.77 IV	IV (III–IV)	IV–V
<i>Mastixia trichotoma</i>	East Kalimantan	2.17 ± 0.51 II	14.79 ± 1.39 IV	19.95 ± 4.80 IV	IV (II–IV)	V
<i>Ficus nervosa</i>	West Java	8.31 ± 1.32 III	9.64 ± 1.91 III	20.12 ± 1.99 IV	IV (III–IV)	V
<i>Triomma malaccensis</i>	Central Kalimantan	7.57 ± 1.57 III	15.78 ± 5.38 IV	15.56 ± 2.65 IV	IV (III–IV)	IV
<i>Horsfieldia glabra</i>	West Java	3.26 ± 0.80 II	11.03 ± 1.42 IV	25.23 ± 1.38 IV	IV (II–IV)	V
<i>Hibiscus macrophyllum</i>	West Java	1.38 ± 0.46 II	24.17 ± 1.38 IV	16.51 ± 2.09 IV	IV (II–IV)	III–IV

(continued)

**Table 2** (continued)

Class	Origin	Weight loss percentage and resistance			Resistance class	
		<i>D. spathularia</i>	<i>P. sanguineus</i>	<i>S. commune</i>	This study *	Seng **
<i>Diospyros macrophylla</i>	East Kalimantan	10.76 ± 1.23 IV	20.44 ± 0.88 IV	11.03 ± 0.90 IV	IV	V
<i>Macaranga pruinosa</i>	Jambi	1.78 ± 0.76 II	26.74 ± 1.68 IV	14.10 ± 0.87 IV	IV (II–IV)	V
<i>Koilodepas</i> sp.	East Kalimantan	4.50 ± 1.88 II	15.77 ± 4.35 IV	22.36 ± 7.27 IV	IV (II–IV)	-
<i>Colona javanica</i>	West Java	7.10 ± 1.04 III	15.17 ± 5.82 IV	21.46 ± 4.43 IV	IV (III–IV)	V
<i>Sloanea sigun</i>	West Java	24.21 ± 4.83 IV	8.07 ± 2.10 III	14.97 ± 3.44 IV	IV (III–IV)	V
<i>Sterculia oblongata</i>	West Java	29.11 ± 5.99 IV	5.56 ± 2.61 III	15.16 ± 2.93 IV	IV (III–IV)	-
<i>Ceiba petandra</i>	West Java	16.42 ± 3.01 IV	18.40 ± 6.59 IV	15.69 ± 1.42 IV	IV	V
<i>Aleurites moluccana</i>	West Java	18.75 ± 7.10 IV	12.49 ± 1.64 IV	20.13 ± 4.19 IV	IV	V
<i>Macaranga gigantea</i>	Jambi	5.38 ± 0.96 III	33.22 ± 5.10 V	13.24 ± 0.41 IV	IV (III–V)	V
<i>Sonneratia caseolaris</i>	Aceh	18.75 ± 2.91 IV	21.27 ± 3.03 IV	14.66 ± 1.43 IV	IV	V
<i>Acer niveum</i>	West Java	20.05 ± 3.86 IV	20.34 ± 4.17 IV	14.88 ± 2.72 IV	IV	IV/V
<i>Ficus vasculosa</i>	West Java	7.21 ± 1.42 III	34.76 ± 8.99 V	13.67 ± 2.13 IV	IV (III–V)	V
<i>Evodia aromatica</i>	West Java	14.94 ± 3.69 IV	24.31 ± 0.38 IV	17.07 ± 2.27 IV	IV	V
<i>Khaya anthotheca</i>	West Java	17.11 ± 3.42 IV	16.32 ± 3.54 IV	22.96 ± 5.12 IV	IV	III–IV
<i>Hopea odorata</i>	West Java	18.93 ± 3.23 IV	16.13 ± 6.62 IV	22.35 ± 7.73 IV	IV	-
<i>Ficus variegata</i>	West Java	10.00 ± 1.89 IV	34.55 ± 9.34 V	12.94 ± 2.56 IV	IV (IV–V)	V
<i>Hevea brasiliensis</i>	West Java	16.28 ± 2.92 IV	10.70 ± 1.31 IV	33.58 ± 6.40 V	IV (IV–V)	V
<i>Litsea</i> sp.	Jambi	4.36 ± 1.15 II	29.15 ± 8.29 IV	28.89 ± 4.04 IV	IV (II–IV)	III–IV
<i>Dracontomelon mangiferum</i>	West Java	25.46 ± 6.99 IV	15.46 ± 4.67 IV	28.61 ± 7.09 IV	IV	IV
<i>Ficus variegata</i>	East Kalimantan	23.06 ± 7.51 IV	26.41 ± 8.93 IV	22.84 ± 5.30 IV	IV	V
<i>Melia excelsa</i>	West Java	30.13 ± 5.67 V	18.67 ± 5.51 IV	27.42 ± 8.89 IV	IV (IV–V)	III–IV
<i>Cinnamomum parthenoxylon</i>	West Java	33.70 ± 4.42 V	22.99 ± 4.72 IV	30.04 ± 4.25 V	IV (IV–V)	IV
Class V (perishable)						
<i>Artocarpus gomezianus</i>	Aceh	48.97 ± 4.19 V	36.08 ± 2.56 IV	17.19 ± 5.07 IV	V (IV–V)	-
<i>Shorea selanica</i>	West Java	38.77 ± 4.54 V	31.27 ± 8.06 V	39.98 ± 3.83 V	V	IV

The weight loss data (%) represent average of six replications; roman numbers explain the resistance classes of wood; \*= resistance tested based on the average weight loss by three fungi species; \*\*= resistance class according to Seng 1990; ± = standard deviation data; - = data not available.

position in the log, and growth site the tree is taken, and what species of tested fungus is used. The ability of fungi to cause weight loss in wood depends on their ability to degrade lignin (Harsh & Tiwari 1990). Weight loss of heartwood due to fungal attack was generally lower than that of sapwood (Suprapti *et al.* 2007). Therefore, it could be assumed that the resistance of heartwood to fungi is higher than that of sapwood, as stated by Coggins (1980) and Khan (1954). The weight losses of wood samples due to the attack of *D. spathularia* were generally low. Higher weight losses were found on samples exposed to

*S. commune* and *P. sanguineus* cultures. This concurs with findings by Luna *et al.* (2004) who reported that weight loss of poplar wood placed on *P. sanguineus* culture for two to five months was 50–60%. However, weight loss of rubber wood (*Hevea brasiliensis*) against *P. sanguineus* was 40.6% (Wong 1988).

From the 85 wood samples tested against *D. spathularia*, 47 species were categorised as resistant (class II), 15 species moderately resistant (class III), 18 species (containing 19 samples) non-resistant (class IV) and 4 species perishable. The capability of *D. spathularia* in degrading

wood was generally low. This was possibly influenced by the intrinsic characteristic of some wood samples which were less susceptible to fungal attack, e.g. *Castanopsis tunggurrut*, *Acacia mangium* and *Litsea odorata*. The resistance of woods against the white rot fungi *P. sanguineus* and *S. commune* was classified into classes II–V. Against the former, 35 wood species were categorised as class II, 17 species class III, 27 species (containing 28 samples) class IV and 5 species, class V. Against *S. commune*, 21 species were categorised as class II, 16 species class III, 44 species (containing 45 samples) class IV and 3 species, class V. It was found that the attacks by these two white rot fungi were more severe than that by *D. spathularia*. Possibly, white rot fungi grew better on wood samples dominated by broad-leaved wood species (hardwood) over conifer (softwood). It has been reported that hardwood is frequently attacked by white rot and softwood by brown rot (Takahashi & Kishima 1973, Schmidt 2006), although in another report, it was observed that both hardwood and softwood are attacked by white rot (Coggins 1980). In this study decay intensity on hardwood by white rot was more severe than that by brown rot fungi. In nature, brown rot fungi occur on softwood but under laboratory conditions it is found that brown and white rot fungi will decay both hardwoods and softwoods (Highley 1987).

Naturally, *P. sanguineus* and *S. commune* are able to grow on almost any kind of wood in Indonesia. Moreover, the three tested fungi are often found growing on the same log. Therefore, for classification purposes it should be based on the average weight loss due to attacks by these fungi as presented in Table 2. No species was categorised as class I but 30 species (35.5%) generally belonged to class II (II to III), while the rest (64.7%) were class III (23.5%), class IV (38.8%) and class V (2.4%). Of the 20 Indonesian wood species tested against *Postia placenta*, *Trametes versicolor* and *Ganoderma applanatum*, 12–13 species are categorised as resistant and highly resistant; the rest as moderately resistant and non-resistant (Sukartana & Highley 1997). However, from a laboratory and grave yard tests on 40 tropical wood species against *Tyromyces palustris*, *Coriolus versicolor* and *Pycnoporus coccineus*, it was observed that 62.5% of the wood species had low durability (class III–V) (Amemiya & Matsuoka 1979).

When compared with other works, results of this study showed that the resistance of *A. mangium* which originated from Bogor, West Java is higher than *A. mangium* from Jasinga (class III) and Banten (class IV), also in West Java (Djarwanto & Suprapti 1998, Suprapti 2002). The resistance of *A. borneensis* (from Bogor) in this study is categorised as class III and this is higher compared with that reported by Djarwanto and Suprapti (1998) for the species from Jasinga (class IV). *Hevea brasiliensis* from Bogor in this study and from Jasinga (Djarwanto & Suprapti 1998) are both in class IV. Growth sites of trees (sources of wood sample) seem to influence wood resistance, and this agrees with findings by Salmiah and Amburgey (1992).

Rasamala wood (*Altingia excelsa*) from Sukabumi, West Java is grouped in class III (III–IV). This is higher than the class IV rasamala wood from Gunung Bunder (Martawijaya 1975) but lower than those originated from Ciwidey which are grouped in class I (Martawijaya 1989).

*Pinus merkusii* from West Java in this study is in resistance class II–III, more resistant compared with that from Sumatera, which belongs to class IV (Martawijaya 1965). However, *Glochidion philippicum* (class II–IV) and *Blumeodendron kurzii* (class III–IV) woods were more resistant than the same species (class V) tested in the field by Sumarni and Muslich (2004).

It was also found that the resistance of *Ficus variegata* originated from East Kalimantan (class IV) is similar to that of the same wood species from West Java (IV–V) but was a little bit higher than the class V reported by Seng (1990). Of the 84 wood species tested, 27 species have similar resistance to samples studied by Seng (1990), 35 are higher and 9 are lower. However, the other 13 species were not observed by Seng (1990). The wood durability classification by Seng (1990) was based on the duration of the wood service life in the field, which varies according to locations and conditions, including the presence of water, fungi, termite and powder-post beetle. The resistance of *Shorea laevifolia* and *S. platyclados* in this study was class II, similar to that reported by Martawijaya (1983) for *S. laevifolia* but higher than *S. platyclados* (class III).

There are about 4000 wood species found in Indonesia, but only a few of them have been classified according to their decay resistance. Therefore, studies concerning the natural decay resistance of wood should be continued.

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## REFERENCES

- AMEMIYA S & MATSUOKA S. 1979. Durability of tropical woods. *JARJA* 13: 256–262.
- CARTWRIGHT ST KG & FINDLAY WPK. 1943. Timber decay. *Biological Reviews* 18: 145–158.
- COGGINS CR. 1980. *Decay of Timber in Buildings Dry Rot, Wet Rot and Other Fungi*. Rentokil Limited Felcourt, East Grinstead.
- DJARWANTO & SUPRAPTI S. 1998. Decay resistance of three wood species against some wood destroying fungi. Pp. 57–62 in Prasetyo B *et al.* (Eds.) *Proceedings of the Second International Wood Science Seminar*. 6–7 November 1998, Serpong.
- DJARWANTO & SUPRAPTI S. 2004. Laboratory testing on the resistance of wood against fungi. Pp. 15–22 in Herjanto E *et al.* (Eds.) *Prosiding Pertemuan dan Presentasi Ilmiah Standarisasi*. 11–12 October 2004. Badan Standarisasi Nasional, Jakarta. (In Indonesian)
- DJARWANTO, SUPRAPTI S & SUDARDJI U. 2007. Deterioration of railway sleeper of wood. Pp. 573–579 in Sunardi *et al.* (Eds.) *Prosiding Seminar Nasional IX MAPEKI*. 11–13 August 2006, Banjarbaru. Fakultas Kehutanan Universitas Lambung Mangkurat, Banjar Baru. (In Indonesian)
- HARSH NSK & TIWARI CK. 1990. Changes in wood components after biodegradation. *Material und Organismen* 25: 137–143.
- HIGHLEY TL. 1987. Changes in chemical components of hardwood and softwood by brown-rot fungi. *Material und Organismen* 22: 39–45.
- HIGHLEY TL. 1991. Degradation of cellulose by brown rot fungi. Pp. 529–530 in Rossmore HW (Ed.) *Biodeterioration and Biodegradation 8: Proceedings of the 8th International Biodeterioration and Biodegradation Symposium*. 26–31 August 1990, Windsor. Elsevier Applied Science, New York.
- KHAN AH. 1954. *Decay in Timber, Its Cause and Control*. Pakistan Forest Research Institute, Abbottabad.
- LUNA ML, MURACE MA, KEYLE GD & OTANO ME. 2004. Pattern of decay caused by *Pycnoporus sanguineus* and *Ganoderma lucidum* (Aphyllophorales) in poplar wood. *IAWA Journal* 25: 425–433.
- MARTAWIJAYA A. 1965. *The Natural Durability of Several Indonesian Coniferous Wood Species*. Report No. 99. Lembaga Penelitian Hasil Hutan, Bogor. (In Indonesian)
- MARTAWIJAYA A. 1975. Laboratory testing on the resistance of wood against fungi. Pp. 775–777 in *Kehutanan Indonesia*. Ministry of Agriculture, Jakarta.
- MARTAWIJAYA A. 1983. Durability of some Dipterocarpaceae wood species. Pp. 157–169 in Martawijaya A *et al.* (Eds.) *Prosiding Pertemuan Ilmiah Pengawetan Kayu*. 12–13 October 1983. Pusat Penelitian dan Pengembangan Hasil Hutan, Jakarta.
- MARTAWIJAYA A. 1989. Durability of woods originated from nature and plantation forests. Pp. 280–288 in Buharman *et al.* (Eds.) *Proceedings Diskusi Sifat dan Kegunaan Jenis Kayu HTI*. Badan Litbang Kehutanan, Jakarta. (In Indonesian)
- MARTAWIJAYA A. 1996. Durability of wood and several factors that affect it. Pp. 1–47 in *Petunjuk Teknis*. Lembaga Penelitian Hasil Hutan, Bogor.
- PILDAIN MB, NOVAS MV & CARMARÁN CC. 2005. Evaluation of anamorphic state, wood decay and production of lignin-modifying enzymes for diatrypaceous fungi from Argentina. *Journal of Agricultural Technology* 1: 81–96.
- SALMIAH U & AMBURGEY TL. 1992. Decay resistance of *Acacia mangium* heartwood against brown and white-rot fungi: preliminary results. *Journal of Tropical Forest Science* 6: 16–20.
- SCHMIDT O. 2006. *Wood and Tree Fungi: Biology, Damage, Protection and Use*. Springer-Verlag, Berlin.
- SENG OD 1990. *Specific Gravity of Indonesian Woods and Its Significance for Practical Use*. Communication No. 13. Forest Products Research and Development Centre, Bogor.
- SUKARTANA P & HIGHLEY TL. 1997. Decay resistance of some Indonesian hardwoods and softwoods against brown and white rot fungi. *Journal of Tropical Forest Products* 2: 160–165.
- SUMARNI G & MUSLICH M. 2004. The durability of 52 Indonesian wood species. *Journal of Forest Product Research* 22: 1–8.
- SUPRAPTI S. 2002. The resistance of mangium (*Acacia mangium* Willd.) wood against eleven wood decaying fungi. *Forest Products Research Bulletin* 20: 187–193.
- SUPRAPTI S, DJARWANTO & HUDIANSYAH. 2007. The resistance of five wood species against thirteen wood destroying fungi. *Journal of Forest Product Research* 25: 75–83.
- TAKAHASHI M & NISHIMOTO K. 1967. Studies on the mechanism of wood decay in infrared spectra of EDNA and SDGI wood as decay proceeds. *Wood Research* 42: 1–12.
- TAKAHASHI M & KISHIMA T. 1973. Decay resistance of sixty-five Southeast Asian timber specimens in accelerated laboratory tests. *Tonan Ajia Kenkyu* 10: 525–541.
- WONG AHH. 1988. Natural decay resistance of kempas (*Koompassia malaccensis*) with included phloem against rot fungi: a laboratory evaluation. *Journal of Tropical Forest Science* 1: 162–169.