

Resistance of Auri (*Acacia auriculiformis* A. Cunn. Ex. Benth.) and Forest Red Gum (*Eucalyptus tereticornis* J.E. Smith) to Philippine Termites

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Abstract

The aim of this study was to determine the resistance of auri (*Acacia auriculiformis*) and forest red gum (*Eucalyptus tereticornis*) against Philippine termites under laboratory and field conditions. An accelerated test on the resistance of the two wood species to the attack of the drywood termite *Cryptotermes dudleyi* and the subterranean termite *Microcerotermes losbañosensis* was conducted following the Standard Protocols of FPRDI. The stake test method was used in evaluating the resistance of both wood species in ground contact to natural populations of subterranean termites.

Results showed that the butt, middle and top portions of *A. auriculiformis* were resistant to both species of termites under laboratory conditions. The degree of damage caused by *C. dudleyi* ranged from 11.0 % to 12.0% while a lower percent termite damage of 1.8% to 3.8% was inflicted on the test blocks by *M. losbañosensis*. All portions of *E. tereticornis* were highly resistant to *C. dudleyi*. Feeding activity of that termite on the wood blocks was manifested by the pellet-like materials noted outside the wood blocks. Likewise, the butt and top portions were highly resistant (0% to 0.5% damage) but the top portion was only resistant (1.4% damage) to *M. losbañosensis*.

Wood stakes regardless of portions of *A. auriculiformis* were 100% invaded by termites after 2.5 years while *E. tereticornis* were all invaded after 2.0 years of exposure. Both wood species exhibited the same level of natural resistance when exposed to the attack of subterranean termites under field conditions. All portions of *A. auriculiformis* and *E. tereticornis* except the top portion were resistant to the attack of subterranean termites with termite damage that ranged from 7.8.0% to 23.0%. The top portion of *E. tereticornis* was moderately resistant with termite

damage of 31.0%. Two species of subterranean termite, *M. gilvus* and *M. losbañosensis*, invaded the wood stakes. None of the test stakes failed after more than 7.0 years of field exposure which showed that *A. auriculiformis* and *E. tereticornis* were classified as highly durable wood species.

Keywords: Auri, *Acacia aurifuliformis*, forest red gum, *Eucalyptus tereticornis*, termites, *Cryptotermes dudleyi*, *Microcerotermes losbañosensis*, *Macrotermes gilvus*

Introduction

Wood remains the most widely used construction materials throughout the world. The rapid increase of population and improper management of forest resources results in the depletion of forest and shortage in the supply of wood. To abate this problem, one alternative solution is the utilization of growing tree species. *A. auriculiformis* is a fast growing species, medium-sized tree and a native to coastal lowlands of Northern Australia, Papua New Guinea and few islands in Eastern Indonesia. The timber is moderately heavy, strong and stable (density ranges 610 to 700 kg/cu m) and is suitable for furniture, door, window and other construction purposes. However, reports showed that most of the fast growing species are considered non-resistant to microorganisms because fast growing species have lower density. (<http://www.banglajol.info/index.php/BJSIR/article/view/8189/6135>).

Forest Red Gum, *E. tereticornis* is another potential species, a native to eastern Australia. Its height ranges from 20 to 50 meters and a diameter at breast height of about 2 meters. The trunk is straight and is usually unbranched for more than half of the total height of the tree. The leaves are used in the production of cineole-based eucalyptus oil (en.wikipedia.org/wiki/eucalyptus_tereticornis) while the wood is used for heavy construction purposes such as railway sleepers, piles, poles and as mining timber. It is also used for fuel wood, charcoal, pulpwood stakes and fence posts, fibre- and particleboard. In Argentina it is used in the manufacture of hardboard for export (FAO Forestry Series No. 11. 1981).

The natural durability of any wood species to termites is important for a rational use of the timber and limits the use of preservatives. Although the two species have proven durable in other countries, information on its natural durability to termites is still wanting under Philippine conditions. It is therefore necessary that such information be generated to formulate measures that will lead to a maximum utilization of said wood species in terms of prolonging their service life.

Materials and methods

a. Accelerated laboratory test on the resistance of Auri and Forest Red Gum to termites

Test insects and preparation of wood blocks

Drywood termites (*C. dudleyi*) and subterranean termites (*M. losbañosensis*) were used as test insects in the resistance test under laboratory conditions. Test blocks with dimensions of 1.0 cm x 2.0 cm x 6.0 cm for *C. dudleyi* and 2.0 cm x 2.0 cm x 6.0 cm for *M. losbañosensis* were prepared from the butt, middle and top portions of defect-free logs of *A. acacia* and *E. tereticornis*. All test blocks were properly labeled, conditioned to 14% MC prior to exposure to termites.

Resistance test under laboratory conditions

One wood block per Petri dish was introduced with 100 workers plus two soldiers of *C. dudleyi*. For test against *M. losbañosensis*, conditioned wood blocks were randomly exposed on top of concrete blocks previously laid out around the active nest implanted into a half-sawn plastic drum filled with soil as termite chamber.

Evaluation of resistance to termites

Resistance of *A. auricularia* and *E. tereticornis* to *C. dudleyi* was evaluated based on the degree of attack at quarterly interval for 12 months. On the other hand, resistance to *M. losbañosensis* was evaluated for four months. Tunnel formation was monitored at monthly interval and the degree of termite damage was rated at the end of the test period. All wood blocks were retrieved and cleaned of dirt after the exposure period. Termite damage of individual samples was visually examined and the degree of attack rated using the following system:

% Termite Damage	Classification
0	Highly resistant (no evidence of termite attack).
1 – 25	Resistant (slightly attacked by termites; from initial nibbling to almost $\frac{1}{4}$ of the wood volume was lost).
26 – 50	Moderately resistant (moderately attacked; more than $\frac{1}{4}$ to more than $\frac{1}{2}$ of wood volume was lost.)
51 – 75	Slightly resistant (severely attacked by termites; more than $\frac{1}{2}$ to almost $\frac{3}{4}$ of the wood volume was lost.)
75 – 100	Non-resistant (destroyed more than $\frac{3}{4}$ of the wood volume was lost.)

Durability test under field conditions

Test stakes from the butt, middle and top portions of the heartwood portions of the bolt were prepared into 5.0 cm x 5.0 cm x 50 cm stakes and oven-dried to 14% MC prior to installation at the FPRDI graveyard test site. The samples were placed in ground about ¼ of their length and inspected monthly for the first 3 months and every 6 months thereafter until failure. A wood stake is considered failed when it incurs more than 75.0% of termite damage.

Wood destroying insects associated with the deterioration of the test stakes were collected and identified. The percent of wood stakes invaded were regularly monitored and the degree of termite damage was rated based on the rating used under laboratory conditions. The durability of *A. auricularia* and *E. tereticornis* was evaluated based on the scheme proposed by Mata (1975).

Service Life	Durability Rating
Less than 1 year	Perishable
1.0- 2.5 years	Non-durable
2.6-4.5 years	Slightly durable
4.6-7.0 years	Moderately durable
> 7.0 years	Highly durable

The evaluation of resistance of wood stakes of *A. auriculiformis* and *E. tereticornis* are ongoing under field conditions. The results presented correspond to the percent termite invasion and termite damage of wood stakes of *A. auriculiformis* and *E. tereticornis* after 7.0 years of exposure.

Results and discussion

Laboratory test on the resistance to termites

Table 1 shows the degree of damage and classification of resistance of *A. auriculiformis* and *E. tereticornis* to termites. Results showed that all portions of both wood species were resistant to both species of termites, *C. dudleyi* and *M. losbañosensis*. Both termite species did not cause any remarkable damage on test wood blocks except for slight attack that ranged from 11.0% to 12.0% damage caused by *C. dudleyi* and 2.8% to 3.8% damaged by *M. losbañosensis* to test blocks of *A. auriculiformis*. On the other hand, all portions of *E. tereticornis* were highly resistant to *C. dudleyi* while it was resistant to highly resistant to *M. losbanosensis*. *Eucalyptus* species are resistant to insect pests and the level of resistance varied significantly between species, locations, and within and between individual trees (Panshin and De Zeeuw 1980). The mechanisms of insect resistance include the structure of leaf surface waxes, cuticle thickness, terpenoid oil and phenol concentrations (Eusebio 1998).

Table 1. Average percent damage and classification of resistance of <i>A. auriculiformis</i> and <i>E. tereticornis</i> to termites under laboratory conditions.				
Portions	<i>A. auriculiformis</i>		<i>E. tereticornis</i>	
	<i>C. dudleyi</i>	<i>M. losbañosensis</i>	<i>C. dudleyi</i>	<i>M. losbañosensis</i>
	% Damage	% Damage	% Damage	% Damage
Butt	12 R	2.8 R	0 HR	0.6 HR
Mid	12 R	1.8 R	0.6 HR	1.4 R
Top	11 R	3.8 R	0.5 HR	0 HR
% Termite Damage	Classification			
0	Highly Resistant (HR)			
1 - 25	Resistant (R)			
26 - 50	Moderately Resistant (MR)			
51 - 75	Slightly Resistant (SR)			
76 - 100	Non-Resistant (NR)			

Field test on the natural durability of *A. auriculiformis* and *E. tereticornis*

Initial termite occurrence of populations of *Macrotermes gilvus* in *A. auriculiformis* stakes was noted after 1.0 year of exposure (Table 2). Earthen termite tunnels were observed on 20.0% to 30% of wood stakes embedded in-ground. The species of termite was identified based on the oval-shape head of soldiers and the wider and easily broken termite tunnels during sampling. The percent of wood stakes invaded increased and ranged from 30% to 80% in year 2.0. Consequently, all *A. auriculiformis* stakes regardless of portions were invaded by termites in 2.5 years.

Foraging activity of another species of subterranean termites, *M. losbañosensis* together with *M. gilvus* occurred at the experimental site within the same test period. *M. losbañosensis* is characterized by the rectangular shape of the soldier head and the narrow, cylindrical and sturdy earthen tunnels on the surface of the wood stakes.

Table 2. Percent of wood stakes of <i>A. auriculiformis</i> and <i>E. tereticornis</i> invaded by subterranean termites after 7 years of exposure under field conditions.														
<i>A. auriculiformis</i>														
	% of Wood stakes invaded by termites													
Portions	0.5 yr	1.0 yr	1.5 Yrs	2.0 yrs	2.5 yrs	3.0 yrs	3.5 yrs	4.0 yrs	4.5 yrs	5.0 yrs	5.5 yrs	6.0 yrs	6.5 yrs	7.0 yrs
Butt	0	20	20	30	100	100	100	100	100	100	100	100	100	100
Mid	0	30	50	80	100	100	100	100	100	100	100	100	100	100
Top	0	30	50	60	100	100	100	100	100	100	100	100	100	100
<i>E. tereticornis</i>														
Portions	0.5 yr	1.0 yr	1.5 Yrs	2.0 yrs	2.5 yrs	3.0 yrs	3.5 yrs	4.0 yrs	4.5 yrs	5.0 yrs	5.5 yrs	6.0 yrs	6.5 yrs	7.0 yrs
Butt	0	0	70	100	100	100	100	100	100	100	100	100	100	100
Mid	20	20	50	100	100	100	100	100	100	100	100	100	100	100
Top	40	40	90	100	100	100	100	100	100	100	100	100	100	100
Each portion of the tree is replicated 10 times.														

The butt portion of *E. tereticornis* was free from termite attack for 1.0 year and termite occurrence in 70% of the wood stakes was noted after 1.5 years. In contrast, 20% of stakes from the mid and 40% of top portion were invaded in 6.0 months. The percent of wood stakes invaded remained unchanged in 1.0 year but increased to 50% to 90% after 1.5 years of exposure. All *E. tereticornis* stakes were invaded by *M. gilvus* and *M. losbañosensis* in 2.0 years. Initial termite invasion of wood stakes was observed at the ground line and termite tunnels extended toward the upper portion of the stake.

Table 3 shows the percent damage of *A. auriculiformis* and *E. tereticornis* stakes after 7.0 years of exposure. The butt portion of *A. auriculiformis* was free from termite attack for 6.0 years despite the early termite invasion of wood stakes in 6.0 months. Wood stakes were highly resistant and sustained only initial nibbling or attempted attack by *M. gilvus* and *M. losbañosensis* within the period. Slight termite damage of 4.0% was noted after 6.5 years and the rate of destruction marginally increased to 8.1% in 7 years. The *A. auriculiformis* stakes from the mid and top portions had no termite attack in 4.5 years. Minimal termite damage of 2.2% and 5.0%

was noted in the mid and top portions, respectively, after 5.0 years of exposure. The rate of damage caused by subterranean termites to mid portion increased correspondingly from 3.3% to 7.8% in 5.5 years to 7.0 years. A similar trend of destruction by termites of the top portion of the wood stakes was noted with slight increase in termite damage of 5.0% to 10.0% within the period. Based on the slight degree of termite attack for more than 7.0 years of exposure, *A. auriculiformis* was classified as highly durable to subterranean termites. The resistance of wood against termites is related to the accumulation of extractives in the heartwood. Flavonoids have an important effect on the durability of wood (Chang et al. 2000, Wang et al. 2004). These secondary metabolites showed strong feeding deterrent activities against the subterranean termite, *Coptotermes formosanus* Shiraki (Ohmura et al. 2000). Sarai et al (1980) and Barry et al. (2005) reported that the heartwood of *Acacia auriculiformis* contains a number of flavonoids and proanthocyanidins. On the other hand, Shultz et al. (1995) claimed that the durability of *Acacia* species was attributed to the presence of dihydromorin and aromadadrin.

Table 3. Percent damage of wood stakes of <i>A. auriculiformis</i> and <i>E. tereticornis</i> caused by subterranean termites after 7 years of exposure under field conditions.															
<i>A. auriculiformis</i>															
Portions	% of Termite Damage														Durability Rating
	0.5 yr	1.0 yr	1.5 Yrs	2.0 yrs	2.5 yrs	3.0 yrs	3.5 yrs	4.0 yrs	4.5 yrs	5.0 yrs	5.5 yrs	6.0 yrs	6.5 yrs	7.0 yrs	
Butt	0	0	0	0	0	0	0	0	0	0	0	0	4.0	8.1	HD
Mid	0	0	0	0	0	0	0	0	0	2.2	3.3	3.3	3.3	7.8	HD
Top	0	0	0	0	0	0	0	0	0	5.0	5.0	5.0	6.0	10.0	HD
<i>E. tereticornis</i>															
Portions															Durability Rating
	0.5 yr	1.0 yr	1.5 yrs	2.0 yrs	2.5 yrs	3.0 yrs	3.5 yrs	4.0 yrs	4.5 yrs	5.0 yrs	5.5 yrs	6.0 yrs	6.5 yrs	7.0 yrs	
Butt	0	0	0	0	0	0	0	1	1	1	6	8	11	13	HD
Mid	0	0	0	0	0	0	0	1	2	3	6	16	22	23	HD
Top	0	0	0	4.5	4.5	5.5	5.5	7.5	7.5	10.5	15	21	29	31	HD
% Termite Damage		Classification				Service Life				Durability Rating					
0		Highly Resistant (HR)				Less than 1 year				Perishable					
1 - 25		Resistant (R)				1.0 - 2.5 years				Non-durable					
26 - 50		Moderately Resistant (MR)				2.6 - 4.5 years				Slightly durable					
51 - 75		Slightly Resistant (SR)				4.6 - 7.0 years				Moderately durable					

76 - 100	Non-Resistant (NR)	> 7.0 years	Highly durable
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In contrast, the wood stakes from the butt and mid portions of *E. tereticornis* had no termite damage in 3.5 years despite the early invasion of termites. Both portions of the wood had very slight termite damage of 1.0% after 4.0 years. The termite damage of stakes from the butt increased from 1.0% to 11.0% while stakes from the mid portion had 2.0% to 22.0% termite attack in 4.5 years to 6.5 years. Only 13.0% and 23.0% termite damage was noted in the butt and middle portion, respectively in 7.0 years. The top portion of *E. tereticornis* had initial termite damage of 4.5% which was noted as early as 2.0 years of exposure. The degree of termite damage increased remarkably to 4.5% to 29.0% in 2.5 years to 6.5 years. The wood stakes suffered moderate damage of 31.0% after 7.0 years. Wood stakes are still sound and field exposure continues. Based on the conditions of the wood stakes after 7.0 years, *E. tereticornis* had shown resistance to the attack of subterranean termites is also classified as a highly durable wood species. The results conformed with the report that this wood species in-ground contact was Class 1 or resistant to termites (<http://www.timber.net.au> –The Australian Database of Timber – Forest Red Gum, http://projects.nri.org/biomass/conference_papers/notes_on_eucalypts.pdf). The incidence of slight to moderate fungal colonization on *A. auriculiformis* and *E. tereticornis* stakes did not cause failure of the samples in the same test period.

Conclusions

It can be inferred from the results of these tests that *A. auriculiformis* is resistant to drywood and subterranean termite attack while *E. tereticornis* is highly resistant to resistant to the same test insects under laboratory conditions. The stake test showed that both wood species did not fail after the 7th year of field testing and therefore are classified as highly durable wood species.

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