

## Biological Resistance of Two Reforestation Woods to Dry Wood Termites

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### ABSTRACT

This work aimed to evaluate the biological resistance of Australian red cedar (*Toona ciliata*) and Eucalyptus woods to the *Cryptotermes brevis* (Kalotermitidae) dry wood termite species. The species used to evaluate natural resistance to insect attacks were Australian red cedar from 6 and 12-year-old plantations installed in the mountainous region of the Espírito Santo state, and commercial adult *Eucalyptus* sp. wood provided by a sawmill located in the South of Bahia state. Fitting and evaluation of the experiment followed the recommendations of the Institute for Technological Research of the State of São Paulo. The three woods differed as to their susceptibility to attack by dry wood termites when the damage caused in the samples was considered, with the most consumed species being the 12-year old Australian red cedar, while the Eucalyptus wood was less susceptible to damage.

**Keywords:** *Toona ciliata*, *Eucalyptus* sp., natural durability, biological assay.

## 1. INTRODUCTION

As a result of the growing scarcity of raw materials of native forest essences and concern for environmental preservation, there has been an increase in using wood from reforestation to meet the needs of industrial segments which are based on solid forestry such as civil construction and the furniture industry. However, wood from implanted forests tends to have a lower natural durability in relation to individuals of the same species occurring in the natural forest. Thus, the resistance to the biological deterioration of wood is an important property and a differential that accredits the same resistance for uses in manufacturing furniture, floors, linings and frames, among other indoor uses. Above all, it provides a greater market value.

This property is related to the wood's ability to resist to the action of biological, physical and chemical deteriorating agents. Thus, it may present high, medium or low resistance to the action of these agents. It is one of the basic requirements that limits its use as sawn material (Oliveira et al., 2017), and the more marked it is, the greater its degree of acceptance in relation to the others (Oliveira et al., 2017), allowing its use without the need for toxic and environmentally harmful chemicals.

Wood is naturally degraded by xylophagous organisms that use the natural polymers of their cell wall as food source, some of which have specific enzymatic systems or are associated with symbiotic organisms, capable of metabolizing them into digestible units (Oliveira et al., 1986). Among the main xylophagous agents that consume wood with great damage to society are termites. They damage buildings and furniture in tropical, subtropical and temperate regions.

Of the more than 2,600 species of termites in the neotropical region, at least 183 are characterized as urban pests and 83 of them cause serious problems, especially in buildings (Su & Scheffrahn, 2000). Those classified as dry wood, which attack wood with low moisture content, have their colonies restricted to the parts being attacked, and underground ones which build their nests in the ground are difficult to combat since they can be at any point of the building or in the surroundings, from where they leave to the forage and consume wood and its derivatives.

Among the dry wood termites, the *Cryptotermes brevis* (Walker) species is the most economically important in Brazil. Even though they form colonies with relatively few individuals, these termites cause significant damage (Myles et al., 2007). The infestation sign of this species is the presence of excrements in granular form. One of the characteristics of this insect is its ease of spreading, being able to be transported in furniture and pieces of wood without being noticed (Foelkel, 2008).

Australian cedar (*Toona ciliata* M. Roem. var. *australis* (F. Muell)), of the Meliaceae family, is from the tropical regions of Australia. The species presents potential for commercial forestry, and may replace native Brazilian cedars supplying redwood as an alternative to reforestation (Ares & Fownes, 2000). This forest species has been seen as an alternative for reforestation by small and medium-sized rural producers in many Brazilian regions, but there is a lack of knowledge on the quality of the produced wood, especially the optimal age for cutting trees.

Australian cedar wood presents technological characteristics similar to those of Brazilian noble species, and can become an alternative, being able to be used in the production of laminates, furniture, cigar boxes and musical instruments (Lamprecht, 1990).

The Eucalyptus genus with its various species has been planted in Brazil to meet the industrial demand for wood for several decades, especially in the steel and cellulose sectors. In addition, some eucalyptus species have been consolidating as raw material for supplying sawn wood, mainly in supplying a processing unit in the south center of Brazil. However, there is still little information on their susceptibility to termite attacks and, according to some studies, certain species are more susceptible than others, generally with low to moderate natural resistance (Paes & Vital, 2000; Silva et al., 2004).

As Australian cedar has reforestation potential for noble wood production and the Eucalyptus genus is the main supplier of solid products, and since there is a lack of information on the natural durability of the wood of both species, this work had the objective to evaluate the biological resistance of Australian cedar (*T. ciliata* var. *australis*) and eucalyptus wood to the dry wood termite *C. brevis* species.

## 2. MATERIALS AND METHODS

The materials used to evaluate the susceptibility to attack by dry wood termites were 6 and 12-year-old Australian cedar (*T. ciliata* var. *australis* (F. Muell)) plantations located in the mountainous region of the Espírito Santo state and commercial adult *Eucalyptus* sp. wood supplied by a sawmill located in the south of the Bahia state.

The method developed by the Technological Research Institute of the state of São Paulo, Timber Division (IPT/Dimad D2) (IPT, 1980) was used to evaluate the biological resistance of the wood. Thus, six samples were selected for each forest species, coming from the region close to the external core, with dimensions of 2.3 × 0.6 × 7.0 cm (radial × tangential × longitudinal), with humidity of ± 12% (dry basis), free from defects (knots, splits and cracks) or stains caused by fungi, tools or cutting equipment. A completely randomized experimental design was used with six replicates in which each experimental unit consisted of a pair of samples subjected to the contact of 40 dry wood termites, 38 workers (pseudo-workers) and two soldiers of the *Cryptotermes brevis* (Kalotermitidae) species.

Glass cylinders with 3.5 cm diameter and 8.0 cm height were used to maintain the insects in contact with the wood samples. These were fixed with paraffin on the wood pairs and the termites were inserted inside them. The set composed of the wood samples and termites was arranged in a Petri dish to avoid their leakage in case of deep scarification or holes which perforated the samples.

Evaluating wood's biological resistance to the termites was comparatively carried out with samples of *Pinus elliottii* (Engel), which has recognized

susceptibility to the attack of these insects, used as control. The assay was installed in a climatic chamber with a temperature of 27 ± 2 °C and relative humidity of 70 ± 4%, for a period of 45 days and with periodic observations. The percentage of dead termites and the number of holes were recorded and attributed a damage score derived from average values of three observers (Table 1) at the end of the test, according to IPT/Dimad D2 (IPT, 1980).

**Table 1.** Evaluation of damage (score) to the studied wood.

Damage	Score
No damage	0
Surface damage	1
Moderate damage	2
Accentuated damage	3
Significant damage (similar to control)	4

Source: IPT (1980).

The variables statistically analyzed by the analysis of variance (F-test,  $p \leq 0.05$ ) were the damage and mortality percentage. Normality (Lilliefors test) and homogeneity of the data variance (Cochran's test) were tested prior to statistical analysis, and it was verified that they followed normal distribution and presented homogeneous variances, not needing to be transformed. The means of the variables were compared by the Tukey test ( $p \leq 0.05$ ).

## 3. RESULTS AND DISCUSSION

For the damage caused to the species exposed to *C. brevis* (Table 2), it can be noted that the eucalyptus wood was less susceptible to attack and could be classified as moderate resistance (Table 1), while the damage to the Australian cedar woods ranged from

**Table 2.** Damage evaluation, termite mortality and holes in samples submitted to the test with *Cryptotermes brevis* dry wood termites in each forest species.

Forestry species	Damage (Score)	Mortality (%)	Holes (Number)
<i>Toona ciliata</i> (6 years)	3.0B (4.4)	53.3A (29.1)	0
<i>Toona ciliata</i> (12 years)	3.7A (6.7)	34.2A (40.8)	6
<i>Eucalyptus</i> sp.	2.4C (16.3)	50.4A (25.1)	0
<i>Pinus elliottii</i> (control)	4.0 A (0.0)	48.7A(14.0)	3

Means followed by the same letter did not differ statistically by the Tukey test ( $p \leq 0.05$ ). Values in parentheses correspond to the coefficient of variation.

accentuated for age 6 to practically significant for 12-year-old wood. It is observed that the wood from the older tree had higher consumption by the insects, being close to the pine wood used as control.

The higher biological resistance of 6-year-old Australian cedar wood trees compared to 12-year-old trees may be related to the secondary components of the wood. This is because young wood has a higher ash content, as in *Eucalyptus grandis* × *Eucalyptus urophylla* hybrids, which in commercial plantations in São Paulo state presented ash contents of 0.41%, 0.31% and 0.18% at the ages of 3, 5 and 7 years, respectively (Bufalino et al., 2012; Moulin et al., 2015; Soares et al., 2015). Woods with higher ash content are less susceptible to attack by dry wood termites (Gonçalves et al., 2013) and by subterranean termites, probably due to the damage that abrasive materials cause to the insects' jaws (Paes et al., 2013). In this sense, the effects of extractives and ash contents on the natural resistance of four woods from the caatinga to xylophagous termites (Paes et al., 2013) were evaluated. The most resistant and less resistant to attack by the *Nasutitermes corniger* (Motschulsky) subterranean termite were *Amburana cearensis* (AC Smith) with ash content of 2.05%, and *Eucalyptus camaldulensis*, whose ash content was only 0.33%.

Ash contents (0.57%) were obtained for Australian cedar (*T. ciliata* var. *Australis*) from residues of a 16-year-old plantation in Marechal Floriano, ES, and for wood from slabs of this same species from Campo Belo, MG, with an age of 4 years, in which an ash content of 1.04% was found (Bufalino et al., 2012). Thus, there is no single characteristic that can be used to relate the attack caused by termites on the wood, according to an experiment carried out to verify the natural durability of ten forest species to dry wood termites (Gonçalves et al., 2013). In this study, the previously mentioned authors presented a damage score equal to 1.73 and ash content of 0.26% for *Eucalyptus cloeziana* wood (F. Muell) and a damage score of 1.07 and ash content of 2.02% for *Eucalyptus torelliana* wood (F. Muell), with both woods being from the São João Evangelista, MG, region. Regarding Australian cedar, wood of this species from trees of 6, 12 and 18 years old indicated that the physical and mechanical characteristics were better for the older trees (Braz et al., 2013).

Australian cedar woods of 6 and 12 years old can be considered young and therefore have low resistance

to *C. brevis* attack. A damage value of 1.9 was found for wood of this same species, which gives it a damage level close to moderate (Gonçalves & Oliveira, 2006). The studied material possibly came from older trees than those used in this study. For the biological resistance of the wood of this forest species at 18 years, which was evaluated using a different methodology from that adopted in this study, a deterioration index (percentage of mass loss) of 1.74% and 6.62% was found for pine wood (Ribeiro et al., 2014).

Among woods from 15 mature *Eucalyptus* trees, *E. grandis* and *E. urophylla* were classified as moderately resistant to *C. brevis* termite attack (Carlos, 1996), therefore being similar to the result found for eucalyptus in this study. However, the *E. tereticornis* wood was classified as non-resistant, while *E. citriodora* (*Corymbia citriodora*) and *E. paniculata* as resistant (Carlos, 1996).

The natural durability of the wood from seven eucalyptus species at the age of 16 years to the attack of dry wood termites indicated that those from *E. grandis*, *E. urophylla*, *E. tereticornis* and *E. pilularis* were more susceptible to attack than those of the species *E. cloeziana*, *E. paniculata* and *E. citriodora*. Values of 1.5 were obtained for *E. citriodora* (*C. citriodora*) wood, and 2.9 for *E. grandis* (Oliveira et al., 2017).

The biological resistance of wood from five eucalyptus species to subterranean termites of the *Nasutitermes* genus indicated that less dense woods (*E. saligna* and *E. urophylla*) were more consumed by termites than those of higher density (*E. cloeziana*, *C. citriodora* and *E. maculata*), which may be associated to the class and quantities of extractives in these woods (Paes & Vital, 2000).

There was no difference between the three tested woods and *Pinus* sp. (control) for insect mortality. However, a lower mortality rate of termites (14.5%) was observed in 12-year-old Australian cedar when compared to the control, which had a similar effect. The higher presence of holes in the samples from this wood in relation to that of 6 years of age and the lower mortality can be attributed to the extractive amount that is toxic to insects and ashes in the wood from younger plants (Gonçalves et al., 2013). Meanwhile, 50% of mortality of termites and an absence of holes in the samples were observed for eucalyptus wood, also indicating the low susceptibility of this wood to the tested insects.

For Australian cedar wood, 69.58% of mortality of termites was obtained (Gonçalves & Oliveira, 2006), but the age of the trees was not reported. The implemented methodology (IPT, 1980) does not present wood resistance classification standards for insect mortality, but the ASTM International (2008) classifies 34 to 66% as moderate mortality and from 67 to 99% as high. It should be noted that this standard is for tests with subterranean termites.

The mortality of dry wood termites in contact with wood from seven Eucalyptus species varied from 27.8% for *E. urophylla* to 35.8% for *E. cloeziana* (Oliveira et al., 2017), and values of 70 and 75% respectively for *E. torrelliana* and *E. cloeziana* (Gonçalves et al., 2013) were also obtained. The differences between insect mortalities submitted to the same forest species may be related to age, site quality and the evaluated part of the wood. No holes were observed for samples from *E. paniculata* and *E. cloeziana* wood (Oliveira et al., 2017) or in those of *E. torrelliana* and *E. cloeziana* (Gonçalves et al., 2013), and up to 15 holes in *E. grandis* (Oliveira et al., 2017).

#### 4. CONCLUSIONS

The less susceptible wood to *C. brevis* attack was eucalyptus and the most consumed was the Australian cedar of 12 years of age, which was similar to the *Pinus* sp. Termite mortality was similar for all tested woods, with exception to the number of holes, being larger for the 12-year-old *Toona ciliata* var. *australis*.

*Toona ciliata* wood was susceptible to the attack of dry wood termites, independently of the evaluated age, with obtained damage for the species at 12 years old being similar to the wood of recognized low natural resistance used as control.

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#### REFERENCES

- American Society for Testing and Materials – ASTM International. ASTM D3345-08: standard method for laboratory evaluation of wood and other cellulosic materials for resistance to termites. In: ASTM International. *Annual Book of ASTM Standards*. West Conshohocken: ASTM International; 2008.
- Ares A, Fownes JH. Productivity, nutrient and water-use efficiency of *Eucalyptus saligna* and *Toona ciliata* in Hawaii. *Forest Ecology and Management* 2000; 139: 227-236. 10.1016/S0378-1127(00)00270-X
- Braz RL, Oliveira JTS, Rodrigues BP, Arantes MDC. Propriedades físicas e mecânicas da madeira de *Toona ciliata* em diferentes idades. *Floresta* 2013; 43(4): 663-670. 10.5380/rf.v43i4.30559
- Bufalino L, Protásio TP, Couto AM, Nassur OAC, Sá VA, Trugilho PF et al. Caracterização química e energética para aproveitamento da madeira de costaneira e desbaste de cedro australiano. *Pesquisa Florestal Brasileira* 2012; 32(70): 129-137. 10.4336/2012.pfb.32.70.13
- Carlos VJ. Resistência a insetos xilófagos. *Preservação* 1996; 21(11): 1-25.
- Foelkel E. *A madeira dos Pinus e sua susceptibilidade ao ataque por cupins-de-madeira-seca e por cupins subterrâneos*. 2008 [cited 2016 May 10]. Available from: <https://bit.ly/2YR63Kf>
- Gonçalves FG, Oliveira JTS. Resistência ao ataque de cupim-de-madeira seca (*Cryptoterme brevis*) em seis espécies florestais. *Cerne* 2006 [cited 2019 May 24]; 12(1): 80-83. Available from: <https://bit.ly/2WpBf5l>
- Gonçalves FG, Pinheiro DTC, Paes JB, Carvalho AG, Oliveira GL. Durabilidade natural de espécies florestais madeiras ao ataque de cupim de madeira seca. *Floresta e Ambiente* 2013; 20(1): 110-116. 10.4322/floram.2012.063
- Instituto de Pesquisas Tecnológicas – IPT. *IPT/DIMAD D2: ensaio acelerado de laboratório da resistência natural ou de madeira preservada ao ataque de térmitas do gênero Cryptoterme (Fam. Kalotermitidae)*. São Paulo: IPT/DIMAD; 1980.
- Lamprecht H. *Silvicultura nos trópicos: ecossistemas florestais e respectivas espécies arbóreas: possibilidade e métodos de aproveitamento sustentado*. Rofsdorf: TZ-Verlag & Print GmbH; 1990.

- Moulin JC, Arantes MDC, Vidaurre GB, Paes JB, Carneiro ACO. Efeito do espaçamento, da idade e da irrigação nos componentes químicos da madeira de eucalipto. *Revista Árvore* 2015; 39(1): 199-208. 10.1590/0100-67622015000100019
- Myles TG, Borges PAV, Ferreira M, Guerreiro O, Borges A, Rodrigues C. Filogenia, biogeografia e ecologia das térmitas dos Açores. In: Borges PVA, Myles T, editores. *Térmitas dos Açores*. Lisboa: Princípiã; 2007. p. 15-28.
- Oliveira AMF, Lelis AT, Lepage ES, Carballeira Lopez GA, Oliveira LCS, Cañedo MD et al. Agentes destruidores da madeira. In: Lepage ES. *Manual de preservação de madeiras*. São Paulo: IPT; 1986. p. 99-278.
- Oliveira JTS, Paes JB, Vidaurre GB. Resistência biológica da madeira de espécies de eucalipto ao ataque de cupins de madeira seca. *Scientia Forestalis* 2017 [cited 2019 May 24]; 45(113): 145-150. Available from: <https://bit.ly/2X3SA16>
- Paes JB, Medeiros Neto PN, Lima CR, Freitas MF, Diniz CEF. Efeitos dos extrativos e cinzas na resistência natural de quatro madeiras a cupins xilófagos. *Cerne* 2013; 19(3): 399-405. 10.1590/S0104-77602013000300006
- Paes JB, Vital BR. Resistência natural da madeira de cinco espécies de eucalipto a cupins subterrâneos, em testes de laboratório. *Revista Árvore* 2000; 24(1): 97-104.
- Ribeiro MX, Bufalino L, Mendes LM, Sá VA, Santos A, Tonoli GHD. Resistência das madeiras de pinus, cedro australiano e seus produtos derivados ao ataque de *Cryptotermes brevis*. *Cerne* 2014; 20(3): 433-439. 10.1590/01047760201420031277
- Silva JC, Lopez GAC, Oliveira JTS. Influência da idade na resistência natural da madeira de *Eucalyptus grandis* W Hill ex. Maiden ao ataque de cupim de madeira seca (*Cryptotermes brevis*). *Revista Árvore* 2004; 28(4): 583-588. 10.1590/S0100-67622004000400012
- Soares VC, Bianchi ML, Trugilho PF, Höfler J, Pereira AJ. Análise das propriedades da madeira e do carvão vegetal de híbridos de eucalipto em três idades. *Cerne* 2015; 21(2): 191-197. 10.1590/01047760201521021294
- Su NY, Scheffrahn RH. Termites as pests of buildings. In: Abe T, Bignell DE, Higashi M. *Termites: evolution, sociality, symbioses, ecology*. Dordrecht: Kluwer Academic Publishers; 2000. p. 437-453.