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Hazard Class H3 field trial to determine the aboveground performance of acetylated radiata pine (Accoya® Radiata) against attack by *Mastoterme darwiniensis*

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Executive Summary

The objective of this study was to conduct a Hazard Class H3 (outside, above ground) field trial to determine the performance of Accoya® Radiata against attack by Australia's most destructive species of termite, *Mastotermes darwiniensis*. The performance of Accoya® Radiata was compared with that of untreated radiata pine sapwood and the naturally durable heartwood of American white oak, PNG Rosewood, spotted gum and western red cedar.

Key Results

The key results of this study were:

- At the conclusion of the field trial all test specimens had evidence of contact by *M. darwiniensis*, and all untreated *Eucalyptus nitens* bait-wood, used as a susceptible and attractive food source for maintaining the presence of termites in exposure containers, had been destroyed.
- The mean mass loss of the untreated radiata pine sapwood was 95%.
- All four of the naturally durable reference heartwood timber samples were significantly attacked by *M. darwiniensis*, with mean mass losses ranging from 49% to 100%. The PNG Rosewood was the most resistant to attack, whilst all of the American white oak test specimens were destroyed.
- The performance of the Accoya® Radiata was markedly superior to that of all the naturally durable reference heartwood timber samples. The mean mass loss was 8.5%.
- Accoya® Radiata would be expected to perform well, and to a much higher level than timbers with equivalent natural durability to those species investigated in this work, against termites in all regions of Australia.

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Introduction

Accsys Technologies PLC has developed a number of acetylated wood-based products designed for use in a range of external construction and joinery applications. The performance of the products against attack by economically destructive Australian termite species is unknown. The objective of this study therefore was to conduct a Hazard Class H3 (outside, above-ground) field trial to evaluate the performance of Accoya® Radiata against attack by Australia's most destructive species of subterranean termite, *Mastotermes darwiniensis*. The performance of Accoya® Radiata was compared with that of untreated radiata pine sapwood and the naturally durable heartwood of American white oak, PNG Rosewood, spotted gum and western red cedar.

Test specimens were exposed in the field for a period of 19 weeks. Full details of the installation of the field trial, and the results obtained, are presented in this report.

Results

At the conclusion of the field trial, all test specimens within the exposure containers had evidence of contact by *M. darwiniensis*. All untreated *Eucalyptus nitens* bait-wood, used as a susceptible and attractive food source for maintaining the presence of termites, had been destroyed.

Data for wood consumption (g) and the corresponding percentage (%) mass loss of individual test specimens are given in Appendix A. A description of the condition of individual test specimens is given in Appendix B. A summary of the mean mass loss data is given in Table 1 and Figure 1. Figures 2 and 3 show the condition of test specimens at the conclusion of the field trial.

Table 1: Mean^a mass loss (g and %) of test specimens after exposure to *M. darwiniensis* in a Hazard Class H3 field trial.

Material Type	Mean^a mass loss (g) (standard error)	Mean^a mass loss (%) (standard error)
Accoya® Radiata	6.22 (2.63)	8.5 (3.6)
Radiata pine sapwood	57.19 (2.14)	94.9 (3.0)
American white oak heartwood	108.77 (1.46)	99.8 (0.2)
PNG Rosewood heartwood	36.48 (10.10)	48.9 (13.5)
Spotted gum heartwood	104.23 (17.65)	83.8 (14.1)
Western red cedar heartwood	27.40 (6.72)	69.3 (16.8)

^aMean of seven test specimens.

The majority of the susceptible radiata pine sapwood test specimens were destroyed or severely attacked by *M. darwiniensis*. The mean mass loss was 95%. These mass losses, together with the destruction of the susceptible *E. nitens* bait-wood, demonstrate that test specimens were subjected to a high level of termite pressure during the field trial. The fact that not all of the susceptible radiata pine sapwood test specimens were completely destroyed by termites reflects the typical variability in relative voracity between different colonies frequently observed in field trials.

All four of the naturally durable reference heartwood timber samples were significantly attacked by *M. darwiniensis*, with mean mass losses ranging from 49% to 100%. The PNG Rosewood was the most resistant to attack, whilst all of the American white oak test specimens were destroyed.

The performance of the Accoya® Radiata was markedly superior to that of all the naturally durable reference heartwood timber samples. The mean mass loss was 8.5%.

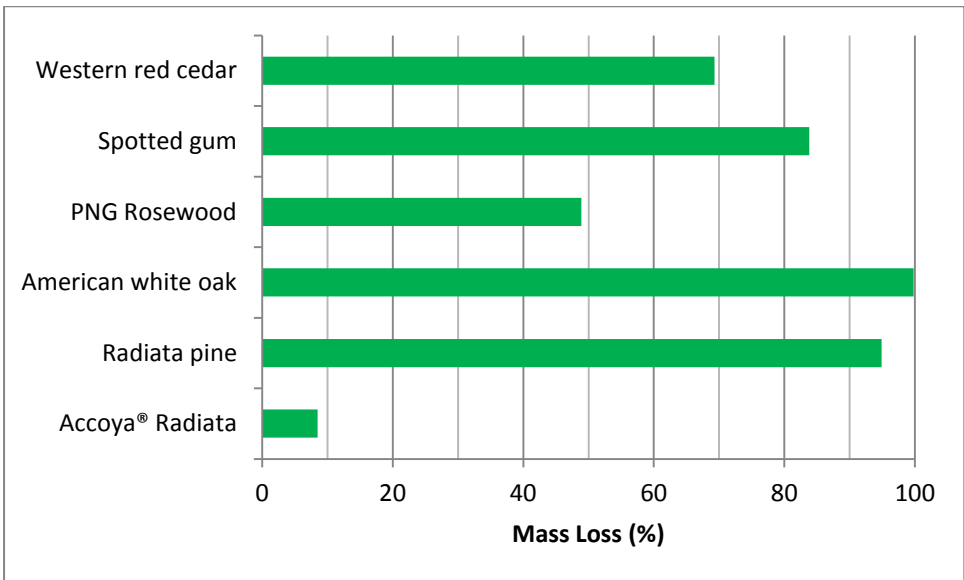


Figure 1: Mean mass loss (%) of test specimens after exposure to *M. darwiniensis* in a Hazard Class H3 field trial.

Conclusions

When exposed to *M. darwiniensis* in the field, the Accoya® Radiata investigated in this study appeared to have markedly superior performance to that of the durable heartwood of all four reference timber species. Accoya® Radiata would thus be expected to perform well, and to a much higher level than timbers with equivalent natural durability to those species investigated in this work, against termites in all regions of Australia.



Figure 2: Condition of a) Accoya® Radiata and b) radiata pine sapwood test specimens after exposure to *M. darwiniensis* in a Hazard Class H3 field trial.

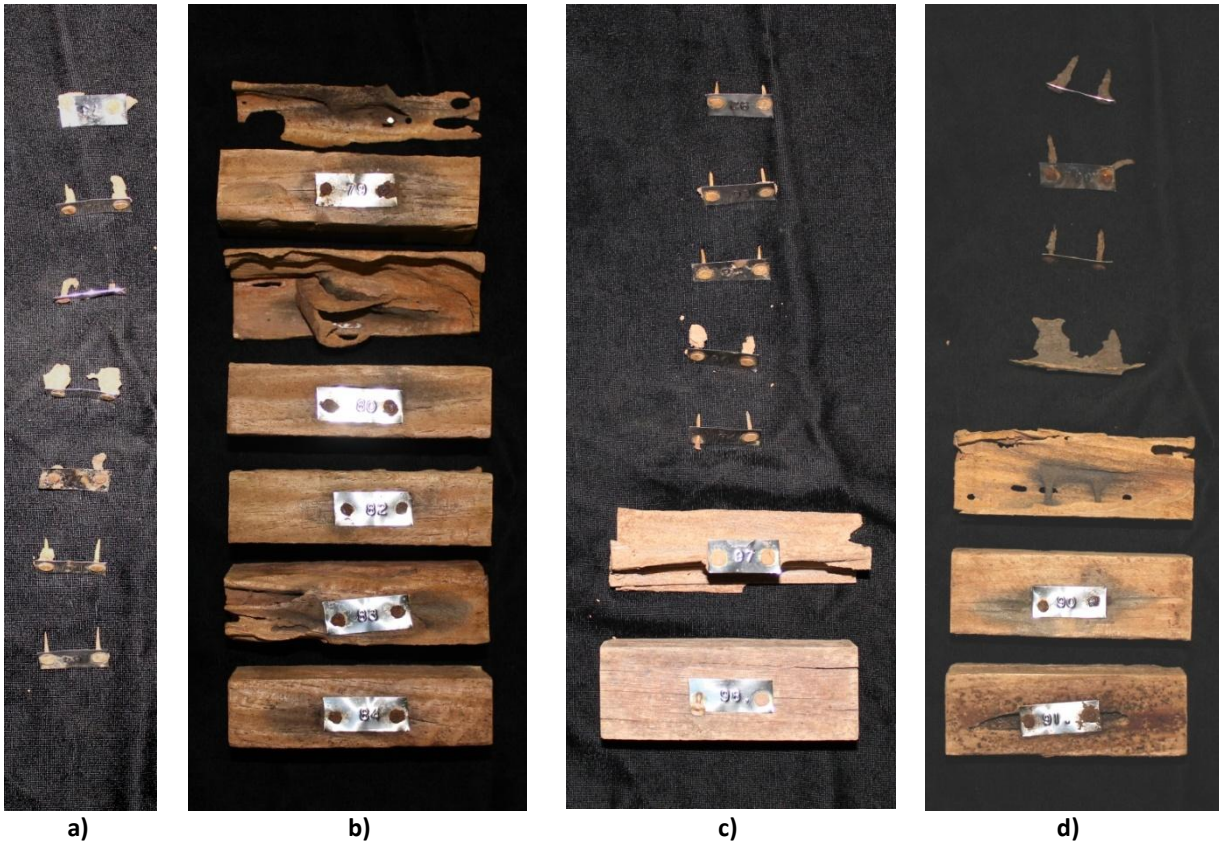


Figure 3: Condition of a) American white oak, b) PNG Rosewood, c) spotted gum and d) western red cedar test specimens after exposure to *M. darwiniensis* in a Hazard Class H3 field trial.

Materials and Methods

Materials

The following were supplied by AFRC:

- Ten test specimens of the following materials, cut from randomly selected stock held at Mathews Timber, Vermont, VIC, Australia:
 - Accoya® Radiata (25 x 50 x 100mm (R x T x L)).
 - Radiata pine (*Pinus radiata* D. Don) sapwood (25 x 50 x 100mm).
 - American white oak (*Quercus alba* L.) heartwood (25 x 50 x 100mm).
 - PNG Rosewood (*Pterocarpus indicus* Willd.) heartwood (25 x 50 x 100mm).
 - Spotted gum (*Corymbia maculata* (Hook.) K.D. Hill & L.A.S. Johnson) heartwood (35 x 35 x 100mm).
 - Western red cedar (*Thuja plicata* Donn ex D.Don) heartwood (35 x 35 x 100mm).
- Stainless steel exposure containers.
- *Eucalyptus nitens* Deane and Maiden (Shining Gum), cut from kiln dried boards (mean air dry density of approximately 700 kg/m³), for use as susceptible bait-wood.
- Secure field test site, known to be inhabited by the subterranean termite *M. darwiniensis*.
- Miscellaneous field supplies and equipment.

Methods

Weathering of test specimens

In accordance with Hazard Class H3 requirements (as specified in the Australasian Wood Preservation Committee Protocols for Assessment of Wood Preservatives (AWPC 2007)¹), all test specimens were leached prior to vacuum oven drying. Test specimens were vacuum-impregnated with water for 30 minutes and then allowed to remain for a further 30 minutes in containers with at least three times the volume of water as of test specimens. Water was drained from the containers and replaced with an equal amount of clean water. The containers were placed in a shaking water bath maintained at 35°C for seven days with the water changed daily during five of the days. Test specimens were then placed on drying racks for two days to surface dry. The test specimens were then artificially weathered in vacuum ovens for five days at 40°C and 0.05 mBar to remove any residual volatiles. After vacuum oven drying, three of the ten test specimens of each material type were assigned as vacuum oven controls, i.e. test specimens that were not exposed to attack by termites. Prior to field exposure, test specimens were labelled with stainless steel tags. Tags were attached to the specimens using brass boat nails.

Test termite

The giant northern termite, *Mastotermes darwiniensis* Froggatt, is a tropical species. The southern limit of its distribution approximates to the Tropic of Capricorn, both in coastal and inland localities. In this zone it is by far the most destructive termite. *M. darwiniensis* is a non-mound builder.²

Test site

A test site at Humpty Doo (12° 38' S, 131° 15' E) in the Northern Territory of Australia was chosen for the field trial as it is known to be inhabited by numerous colonies of *M. darwiniensis*. Mean annual temperature for the site is 27.6°C and mean annual rainfall is 1666 mm.

¹ AWPC. (2007). *Protocols for Assessment of Wood Preservatives. Revised edition*. Australasian Wood Preservation Committee. (www.tpa.com.au).

² Gay, F.J. and Calaby, J.H. (1970). *Termites in the Australian region*. In Krishna, K and Weesner, F.M. (Eds). *Biology of Termites*, Vol. II. 643 pp. New York and London, Academic Press, pp. 393-448.

Field trial

The test method adopted for the field trial, a modified 'drum technique', satisfies the minimum requirements for evaluating timber intended for Hazard Class H3 service conditions (outside, aboveground)¹. Seven exposure container base units were placed over freshly cut tree stumps that contained active galleries of *M. darwiniensis*. *E. nitens* bait-wood was then placed inside the base units to encourage foraging by termites. When these were observed to be active, the main 20-litre stainless steel exposure containers (with perforated bases) were placed over the base units. A layer of termite-susceptible *E. nitens* bait-wood was placed inside the base of each exposure container. One replicate test specimen of each timber sample was then placed inside each exposure container separated by *E. nitens* spacers. The spacers served as an additional source of attractive bait-wood for termites as well as linking test specimens together. Additional *E. nitens* bait-wood was then placed around and on top of the test specimens to attract termites into the exposure containers and to maintain their presence for the test duration. Vented lids sealed the containers (see Figure 4).

Each exposure container was linked to termites from a different colony of *M. darwiniensis*. This was achieved by ensuring that the distance between containers exceeded the likely foraging range expected of *M. darwiniensis*.

For protection against excessive heat and grass fires, exposure containers were insulated with aluminium building sisalation. The trial was installed on 4th December 2012. Its duration was determined by the time taken for termites to consume all palatable material and vacate the exposure containers.

Assessment

At the conclusion of the field exposure period, test specimens were removed from the exposure containers and cleaned. All the test specimens, including the vacuum oven controls, were then vacuum oven dried for five days at 40°C and 0.05 mBar; they were then cooled and weighed. Any changes in mass of the vacuum oven controls were used to adjust the mass losses of test specimens exposed to termites in the field. The condition of exposed test specimens was also assessed visually to confirm that measured mass losses were attributable to termite attack.



Figure 4: Exposure container containing test specimens and bait-wood, connected to active galleries of *M. darwiniensis*, prior to wrapping in sisalation to protect the contents against excessive heat and fire.

Appendix A: Mass loss (g and %) of test specimens after exposure to *M. darwiniensis*.

Material Type	Specimen No.	Mass loss (g)	Mean mass loss (standard error) (g)	Mass loss (%)	Mean mass loss (standard error) (%)
Radiata pine sapwood	50	59.84	57.19 (2.14)	98.1	94.9 (3.0)
	51	61.91		100.0	
	52	59.46		98.1	
	53	54.51		88.6	
	54	61.73		100.0	
	55	45.82		79.4	
	56	57.04		100.0	
Accoya® Radiata	43	3.03	6.22 (2.63)	4.1	8.5 (3.6)
	44	3.41		4.7	
	45	6.25		8.7	
	46	1.99		2.7	
	47	6.90		9.2	
	48	21.18		29.2	
	49	0.77		1.1	
American white oak heartwood	71	102.49	108.77 (1.46)	100.0	99.8 (0.2)
	72	104.42		100.0	
	73	108.61		100.0	
	74	110.95		98.8	
	75	112.50		100.0	
	76	110.55		100.0	
	77	111.89		100.0	
PNG Rosewood heartwood	78	72.03	36.48 (10.10)	95.1	48.9 (13.5)
	79	5.51		7.4	
	80	40.95		55.9	
	81	57.98		78.2	
	82	52.41		71.1	
	83	24.33		31.4	
	84	2.14		3.1	
Spotted gum heartwood	92	126.24	104.23 (17.65)	100.0	83.8 (14.1)
	93	125.67		100.0	
	94	125.93		100.0	
	95	126.37		100.0	
	96	121.06		100.0	
	97	104.47		86.7	
	98	-0.14		-0.1	
Western red cedar heartwood	85	41.22	27.40 (6.72)	99.9	69.3 (16.8)
	86	40.51		99.9	
	87	40.38		99.9	
	88	30.33		79.8	
	89	35.41		95.5	
	90	1.87		4.7	
	91	2.04		5.2	

Appendix B: Condition of test specimens after exposure to *M. darwiniensis*.

Material Type	Specimen No.	Condition
Radiata pine sapwood	50	Destroyed
	51	Destroyed
	52	Destroyed
	53	Extensive attack – virtually destroyed
	54	Destroyed
	55	Extensive attack – virtually destroyed
	56	Destroyed
Accoya® Radiata	43	Slight attack – widespread grazing on all faces and edges. Two penetrations in end grain to a depth of 20mm
	44	Slight attack – widespread grazing on all faces and edges. Three penetrations in end grain to a depth of 40mm
	45	Moderate attack – widespread grazing on all faces and edges. Penetration in end grain through entire 100mm length of specimen
	46	Slight attack – widespread grazing on all faces and edges. Three penetrations in end grain to a depth of 20mm
	47	Moderate attack – widespread grazing on all faces and edges. Six penetrations in end grain, one through entire 100mm length of specimen
	48	Significant attack – widespread grazing on all faces and edges. Six major penetrations in end grain, one through entire 100mm length of specimen
	49	Slight attack – localised grazing on all faces and edges
American white oak heartwood	71	Destroyed
	72	Destroyed
	73	Destroyed
	74	Destroyed
	75	Destroyed
	76	Destroyed
	77	Destroyed
PNG Rosewood heartwood	78	Destroyed
	79	Moderate attack – widespread grazing on all faces and edges. Two large penetrations of end grain to a depth of 60mm
	80	Significant attack – widespread grazing on all faces and edges, specimen hollowed out
	81	Extensive attack – virtually destroyed
	82	Extensive attack – virtually destroyed
	83	Significant attack – widespread grazing on all faces and edges. Two large penetrations of end grain, one through entire 100mm length of specimen
Spotted gum heartwood	92	Destroyed
	93	Destroyed
	94	Destroyed
	95	Destroyed
	96	Destroyed
	97	Extensive attack – virtually destroyed
	98	Slight attack – localised grazing, mainly on edges
Western red cedar heartwood	85	Destroyed
	86	Destroyed
	87	Destroyed
	88	Extensive attack – virtually destroyed
	89	Destroyed
	90	Slight attack – widespread grazing on all faces and edges. One penetration on end grain to a depth of 20mm
	91	Slight attack – widespread grazing on all faces and edges. Deep groove on one face to a depth of 20mm