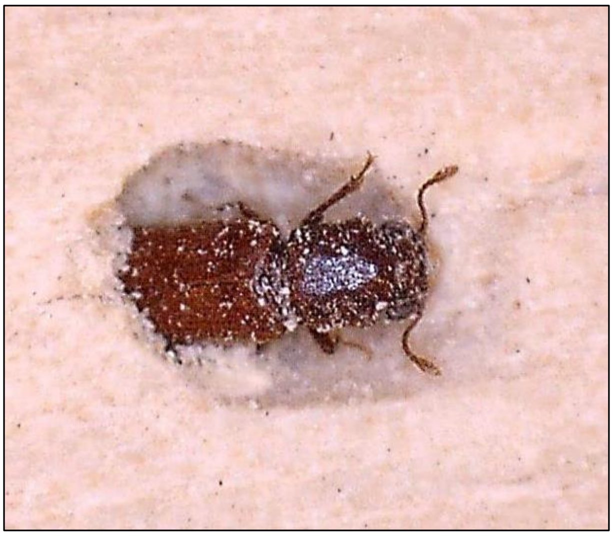
ACIAR FST/2009/062 Development of advanced veneer and other products from coconut wood to enhance livelihoods in South Pacific communities

DAF Report – Susceptibility of cocowood to lyctid beetle and bamboo borer infestation

March 2016



Queensland Government

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Summary

Five exposure trials (a combination of “outdoor” and laboratory trials) were undertaken to assess the susceptibility of cocowood, of varying densities, to attack by lyctid beetles (*Lyctus* sp. and *Lyctus brunneus*) and bamboo borer (*Dinoderus minutus*). Both insect groups are significant pests when considering timber, bamboo and other similar products. Published information of the susceptibility of cocowood to lyctid beetle and bamboo borer infestation is limited.

Three exposure trials were established with a focus on either wild colonies of lyctid beetles or cultured colonies of *Lyctus brunneus.* Trial locations varied from outdoor locations within the Department of Agriculture and Fisheries’ (DAF) Salisbury Research Facility to laboratory trials with confined exposures within either glass jars or plastic containers. A total of 120 cocowood blocks, selected from five nominal density groups and 125 control blocks (spotted gum and blackbean sapwood) were exposed targeting lyctid beetle infestation. Trial exposure periods ranged from 6-18 months. At the completion of the trials, no cocowood block contained any evidence of infestation by lyctid beetles.

Two trials were established to expose cocowood blocks to bamboo borers. The trials included exposure to either wild colonies of bamboo borers within DAF’s Salisbury Research Facility or contained exposures within purpose-built cages. A total of 150 cocowood blocks, selected from five nominal density groups, and approximately 200 bamboo rings (either actively infested or freshly cut) were exposed targeting bamboo borer infestation. Trial exposure periods ranged from 3-8 months. At the completion of the trials, no cocowood block contained any evidence of infestation by bamboo borers.

The results of these trials provide confidence that wood from the coconut palm stems can be used for the manufacture of wood-based products without the need for any additional processing requirements (e.g. chemical treatment) to be protected from infestation by lyctid beetles or bamboo borers.

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1 Introduction

Lyctid beetles (*Lyctus* sp. and *Lyctus brunneus* S.) and bamboo borers (*Dinoderus minutus F.*) mainly refer to insect pest groups of major importance when considering timber, bamboo and other similar products. Lyctid beetles cannot produce cellulases and are thus restricted to the sapwood or starch-containing material, which the larvae reduce to a fine soft powder (Garcia and Morrell 2009; Peters *et al* 2002). Initial attack by lyctid beetles is difficult to detect and will often go unnoticed until the infestation is much further advanced (Kalawate, 2013). Lyctid beetles are a common and major pest for the hardwood timber industry. Control measures are well understood and commonly adopted by the timber industry worldwide (such as chemical treatment or total sapwood exclusion from products). *Dinoderus minutus*, commonly referred to as the bamboo borer or “Ghoon”, is one of the most significant pests of bamboo and cane type products. Both pest groups will not infest softwoods i.e. pines, nor will they infest the heartwood of hardwood timbers.

After mating, the female lyctid beetle lays eggs in the pores of the sapwood of the susceptible hardwood. Some 14 days later, eggs hatch into small larvae which feed on the starch in the sapwood until fully grown. The larval period may occupy 2–12 months, depending on the temperature, humidity and the abundance of food i.e. concentration of starch in the sapwood (Hadlington and Geroziosis 2008). In adverse conditions, the lifecycle can be as long as 18 months (Kalawate 2013). Tunnels usually follow the grain of the wood and it is the larval stage which is primarily responsible for the destruction of timber. Following a short pupal period (15–20 days), mature beetles begin to emerge through the surface of the infested timber, leaving a round hole (1–2 mm diameter) as each emerges. Small piles of frass (discarded and excreted material) associated with the emergence holes may collect on the surface of infested timber or fall nearby. The presence of this frass is usually the first sign the timber is infested. The frass is smooth and floury in appearance. Adults only live for 2–5 weeks and must find suitable oviposition sites during this time (Kalawate 2013).

The mated female bamboo borer enters bamboo or similar materials from the cut surfaces, particularly the end surfaces of culms and oviposits inside. This differs from the lyctid beetle where oviposition takes place on the surface of the susceptible timber. The larvae develop by boring into and feeding on the parenchyma tissue near the inner surface of the culms (Watanabe *et al* 2016). The adults also feed after they emerge from the pupal stage in order to obtain nutrients and similar to lyctid beetles, emerge via an exit hole to mate. The female can lay up to 35 eggs at a time and the eggs can hatch in as little as five days (Hickin 1975). The larva undergoes up to four development phases during an average 40-day period before it pupates. As with lyctid beetles, the larval period can be as short as 2–3 months but can be much longer under adverse conditions, especially when the starch content of the infested material is low (Hickin 1975).

The presence of borer holes and a powdery frass regularly ejected from the cut ends are manifestations of an infestation. Compared to the frass from lyctid beetles, the frass of the bamboo borer is coarser and the cellular structure is still recognizable under a microscope.

Re-infestation by both pest groups is common and may continue until the food source is completely consumed. Evidence of an infestation may not become apparent until after the material (e.g. timber, bamboo, cane etc) has been manufactured into a product and adults begin to emerge in combination with powdery frass. With severe attack, the whole of the infested area may be reduced to powder leaving only a shell on the outside, perforated by emergence holes.

There is currently no information on the susceptibility of wood from the stem of a coconut palm (*Cocos nucifera* L.) to either lyctid beetles or bamboo borers. Expanding the utilisation of coconut wood (cocowood) and coconut rotary-veneer (cocoveneer) is being actively pursued, especially in the South Pacific region. An understanding of potential insect threats is necessary to guide processing and manufacturing strategies and protocols for coconut-based products.

Cocowood is different from traditional wood in that it is a monocotyledon (belonging to the grass family) and not a “true” wood (dicotyledon). Bootle (2010) reports that coconut wood has “no lyctid borer problems” but there is no reference to any scientific testing. The fact that cocowood is a monocotyledon suggests it may not be prone to lyctid beetle attack (females would be unable to oviposit due to the absence of vessels or pores compared to hardwoods). However, to provide further confidence, a number of exposure trials with known lyctid susceptible sapwood as a control and cocowood as the test sample were established to ascertain susceptibility or resistance of cocowood to lyctid beetle attack.

Bamboo has much greater similarities to cocowood compared to traditional wood in that it too is a monocotyledon, however, it is unknown if bamboo borers are a threat to cocowood. Exposure trials to ascertain the susceptibility of cocowood to bamboo borer attack were also established.

2 Material and methods

To determine the potential susceptibility of cocowood to lyctid beetles and bamboo borers, five different exposure trails were established. These included:

1. Trial 1 – outdoor exposure trial to wild colonies of *Lyctus* sp.
2. Trial 2 – laboratory exposure trial to *Lyctus brunneus*
3. Trial 3 – laboratory exposure trial to *Lyctus* sp.
4. Trial 4 – outdoor exposure trial to *Dinoderus minutus*
5. Trial 5 – laboratory exposure trial to *Dinoderus minutus.*

Test materials included:

1. Cocowood;
2. Lyctid susceptible hardwood (two species); and
3. Bamboo.

2.1 Test and control blocks

Cocowood samples of varying densities were selected (by visual assessment of vascular bundle pattern) from stocks stored at the Department of Agriculture and Fisheries' (DAF) Salisbury Research Facility to provide a range of test specimens from high density (tightly packed vascular bundles) to low density (loosely packed vascular bundles). Five nominal density groups were chosen with a decreasing concentration of vascular bundles when viewed from the end cross-section (Image 1). The five nominal density groups were labelled as:

- High density (HD);
- Medium high density (MHD);
- Low high density (LHD);
- Medium density (MD); and
- Low density (LD).

Image 1. Examples of five cocowood density groups (L to R – HD, MHD, LHD, MD and LD).

From the selected cocowood boards, test blocks were cut to be used in the various exposure trials. In addition, test blocks containing predominately sapwood were cut from boards of spotted gum (*Corymbia citriodora* subsp. *variegata)* and blackbean (*Castanospermum australe)*. Given the difficulty to visually confirm the sapwood and heartwood boundary in spotted gum, the ends of a subset of the spotted gum blocks were sprayed with a methyl orange solution enabling confirmation that sapwood dominated the sample cross-section (Image 2).

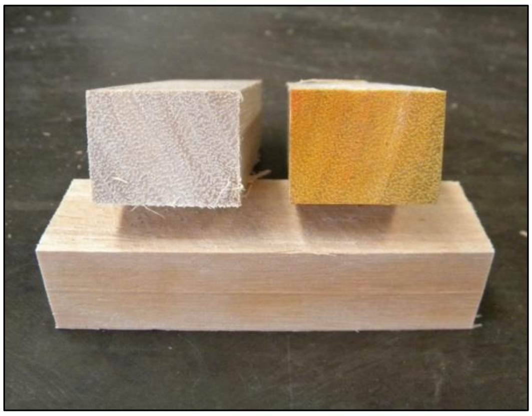

Image 2. Sapwood blocks of spotted gum with the block on the right sprayed with methyl orange to confirm a high percentage of sapwood. Yellow colour confirms sapwood.

The Australian Wood Preservation Committee (AWPC) test protocol for laboratory trials with lyctid beetles require a minimum dimension of 18 × 25 × 75 mm for test blocks where preservative treatments (to prevent lyctid beetle attack) are assessed (Australian Wood Preservation Committee 2015). In line with this protocol, test blocks were prepared to a nominal dimension of 20 × 25 × 80 mm.

Bamboo samples were also prepared by cutting ‘rings’ from bamboo sourced from a commercial planting near Tairo, Queensland. The rings ranged in diameter and where cut to a nominal length of 70 mm.

2.2 Exposure trial 1: *Lyctus* sp. (lyctid beetle)

The DAF Salisbury Research Facility is known to harbor “wild” colonies of lyctid beetles. Susceptible timber within the facilities storage areas provide evidence of past and current lyctid beetle infestation (borer holes and powdery frass).

Ten cocowood blocks were randomly selected from each of the five nominal density groups providing a total of 50 test blocks. Fifty spotted blocks and 50 blackbean blocks were also randomly selected providing 100 control blocks.

Each cocowood block was grouped with a spotted gum and a blackbean block to provide a test set. Each test set (Image 3) was placed at various locations within the timber storage areas of the DAF Salisbury Research Facility where lyctid beetles have been active (demonstrated by attacked timber and powdery frass being present) (Images 4 and 5). The blocks remained in position for approximately 18 months providing adequate time for infestation by "wild" populations of lyctid beetles. Regular inspections took place during this period to examine for any external signs of infestation in the blocks, particularly the sapwood controls which would provide confidence that active colonies are present.

At the completion of the exposure period, each test block (cocowood and control blocks) was visually inspected for any signs of lyctid beetle attack on the surface of the block before being broken apart to assess the blocks internally.

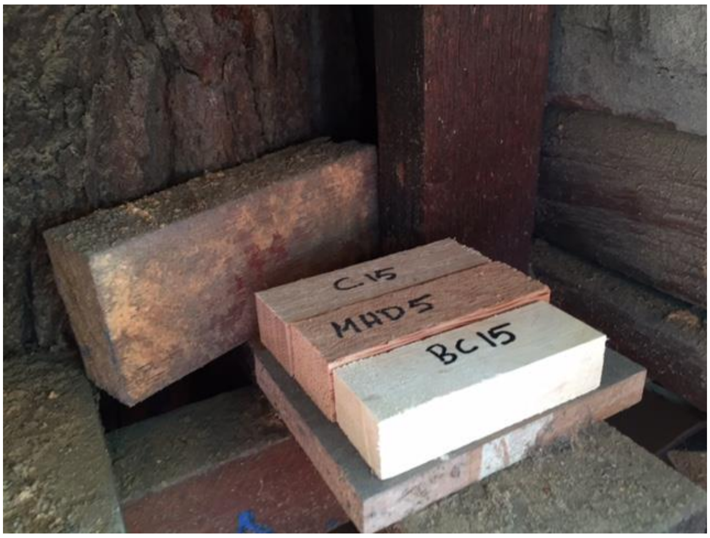

Image 3. A cocowood test block adjacent to a spotted gum (C) and blackbean (BC) control block in a timber storage area at the DAF Salisbury Research Facility.

Image 4. Signs of a previous lyctid beetle infestation (borer holes and powdery frass) in a timber storage area at the DAF Salisbury Research Facility.

Image 5. Cocowood and control blocks placed in close proximity to previous lyctid beetle infestations.

2.3 Exposure trial 2: *Lyctus brunneus* (lyctid beetle)

Trial 2 was conducted at the DAF Salisbury Research Facility and included 20 randomly selected cocowood blocks (5 density groups × 4 replicates) each paired with a blackbean control block. Each pair of blocks were positioned in a traditional testing jar (Mason 500 ml glass jar with perforated lid).

Artificial culture medium containing *L. brunneus* adults was used to inoculate each jar (Images 6 and 7). The inoculation process guaranteed that a small number of live beetles (including females) were placed in each jar.

The lyctid beetles used for this trial were supplied (with species confirmed) by the Australian Forest Research Company Pty. Ltd (AFRC).

The jars were positioned in a darkened room at 25˚C for approximately six months with regular inspections to identify any lyctid beetle infestation in the test blocks. After six months exposure, each cocowood and control block was visually inspected for any signs of lyctid beetle attack on the surface before being broken apart to assess inside the blocks.

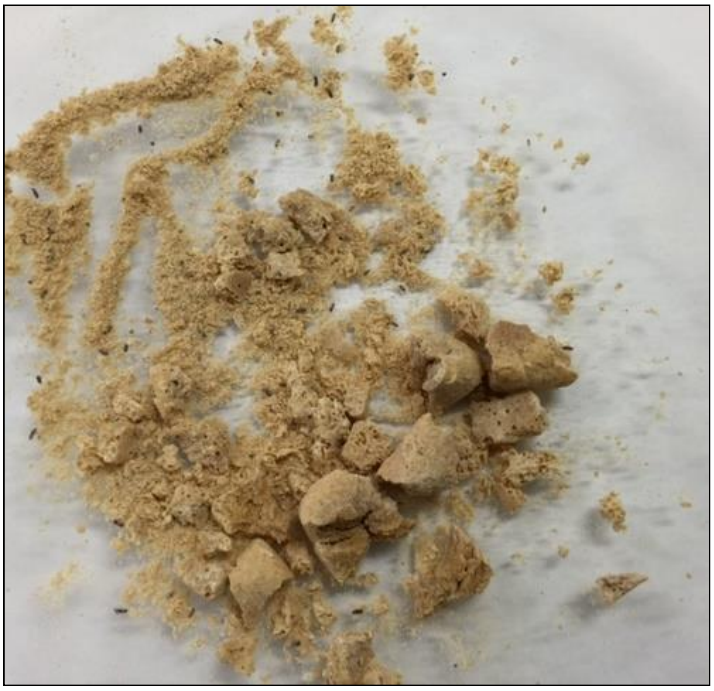

Image 6. Artificial medium containing live* L. brunneus *adult beetles.

Image 7.* L. brunneus *adults on a control test block before being placed in a glass jar with a cocowood test block and some culture medium.

2.4 Exposure trial 3: *Lyctus* sp. (lyctid beetle)

Exposure trial 3 was conducted within the laboratories of AFRC and constituted 50 randomly selected cocowood blocks (5 density groups × 10 replicates) and five blackbean control blocks. Five plastic storage containers were set up, each containing 10 cocowood test blocks and one blackbean sapwood block together with a small section of lyctid-infested blackbean sapwood (Image 8). Live adults, fresh emergence holes and powdery frass were all evident in each of the storage containers when the trial was established (Image 9).

Image 8. Cocowood and blackbean control blocks were placed in plastic storage containers with sections of lyctid-infested blackbean sapwood.

Image 9. Lyctid-infested blackbean sapwood with exit holes and white powdery frass where adults had newly emerged.

The containers were placed in a controlled environment room (25°C and 75% RH) for approximately six months (Image 10). The external surfaces of the blocks were inspected regularly to identify any lyctid beetle infestation. After six months exposure, half of the cocowood blocks (5 density groups × 5 replicates) were returned to DAF for destructive assessment. The remainder were left in-situ for further exposure.

Image 10. The containers were stored in a controlled environment room for the exposure period.

2.5 Exposure trial 4: *Dinoderus minutus* (bamboo borer)

Exposure trial 4 was established at the DAF Salisbury Research Facility to assess cocowood susceptibility to the bamboo borer. Fifty randomly selected cocowood blocks (5 density groups × 10 replicates), 50 bamboo rings that contained active bamboo borer infestation and approximately 50 freshly cut bamboo rings were used for the exposure trial. Combinations of cocowood blocks with either infested bamboo rings, with freshly cut bamboo rings or with both infested and freshly cut rings were placed at various locations within the facility. The sample locations favoured positions where unrelated bamboo products and samples were stored therefore increasing the likelihood of borer presence (Image 11). After eight months exposure, each cocowood block was assessed externally for evidence of bamboo borer infestation (small holes and/or powdery frass). Half of these blocks were broken apart and assessed internally.

Image 11. Cocowood blocks, bamboo borer infested bamboo rings and freshly cut bamboo rings were placed at various locations within the DAF Salisbury Research Facility.

2.6 Exposure trial 5: *Dinoderus minutus* (bamboo borer)

Similar to exposure trial 4, trial 5 was established to assess cocowood susceptibility to the bamboo borer, however for trial 5, insect cages were used to confine the borers in closer proximity to the cocowood blocks. Two cages were initially established with 50 cocowood blocks (5 density groups × 10 replicates) randomly spread between the 2 cages along with approximately 50 bamboo borer infested bamboo rings (Images 12 and 13). After six months exposure, each cocowood block was assessed externally for evidence of bamboo borer infestation (small holes and/or powdery frass). Half of these blocks were broken apart and assessed internally.

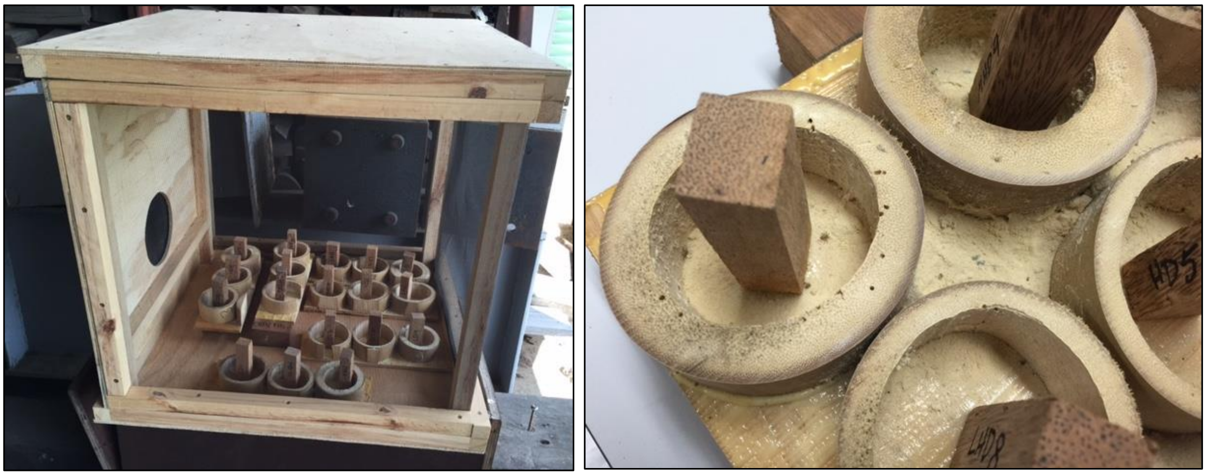

Image 12. Cocowood blocks and bamboo borer infested bamboo rings in exposure cages.

Image 13. Live adult bamboo borers were recovered from bamboo rings used in the cage trial.

After approximately three months, an additional two cages were established to replicate the earlier cages (i.e. 50 cocowood blocks and approximately 50 bamboo rings) using fresh borer infested bamboo rings (Image 14). The blocks and rings were spread throughout the two cages with non-infested rings being placed on top of the infested rings (Image 15). This was to encourage fresh infestation and re-infestation for an on-going strong viable colony of bamboo borers. However, at the time of report preparation, the exposure period was only three months. The final assessment of the cocowood blocks within these cages will be assessed after six months of exposure.

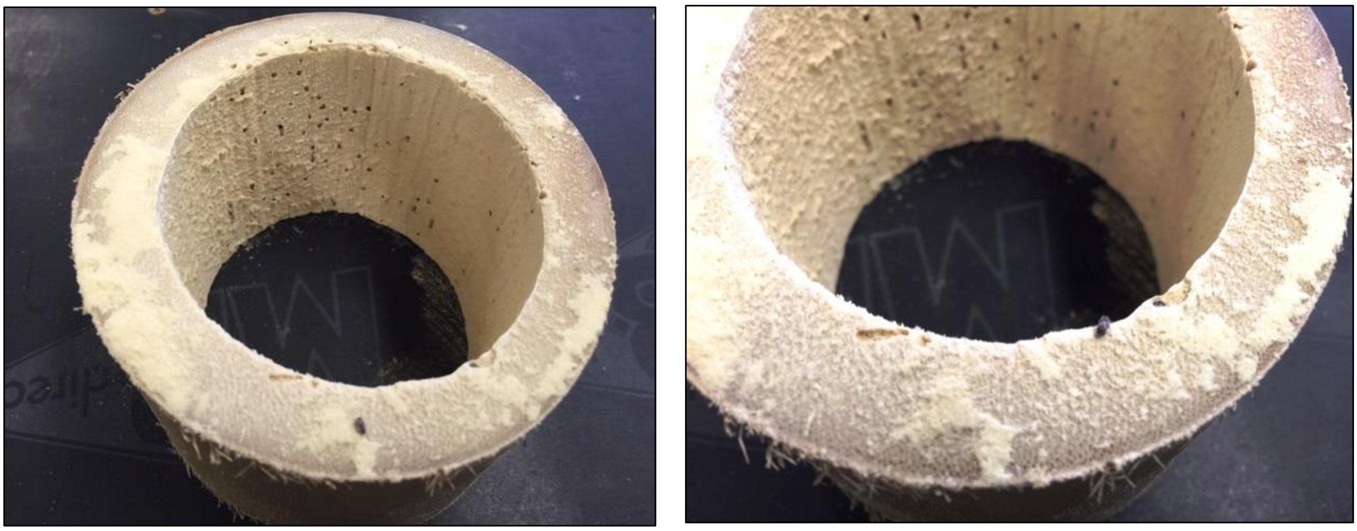

Image 14. Bamboo borer infested bamboo rings prepared and ready for installation in cages.

Image 15. Bamboo rings with active borer infestation (note the build-up of powdery frass) were used in a cage trial with cocowood blocks of varying densities.

3 Results

3.1 Exposure trial 1: *Lyctus sp.* (lyctid beetle)

During and at the completion of the exposure period, all 150 blocks were inspected externally for evidence of lyctid beetle infestation. At the end of the exposure period, the blocks were also broken apart to determine if any evidence of infestation existed within the blocks. There was no evidence of lyctid beetle infestation in any of the cocowood blocks (Image 16). Only three control blocks (one spotted gum and two blackbean) contained lyctid beetle infestation at the end of the exposure period (Images 17 and 18).

Image 16. Cocowood block examples broken apart with no evidence of lyctid beetle infestation.

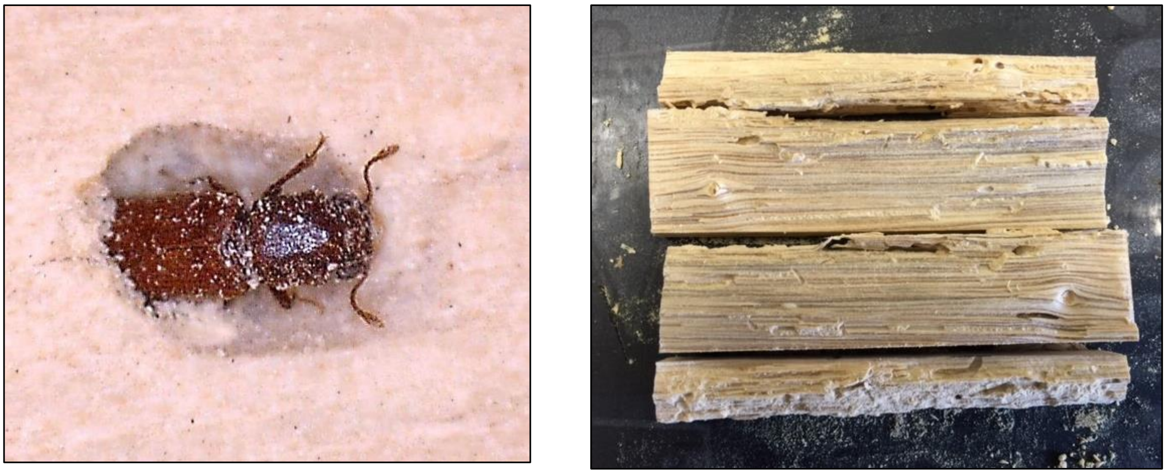

Image 17. Live lyctid beetle found emerging from a spotted gum control block – subsequent destructive sampling revealed a larval gallery and powdery frass.

Image 18. Blackbean control block with lyctid beetle infestation externally visible adjacent to a cocowood block.

3.2 Exposure trial 2: *Lyctus brunneus* (lyctid beetle)

At the completion of the exposure period, 15 of the 20 blackbean control blocks had confirmed lyctid beetle infestation based on the presence of adult beetle emergence holes and internal damage (Images 19 and 20). There was no evidence of infestation in the remaining five blackbean control blocks.

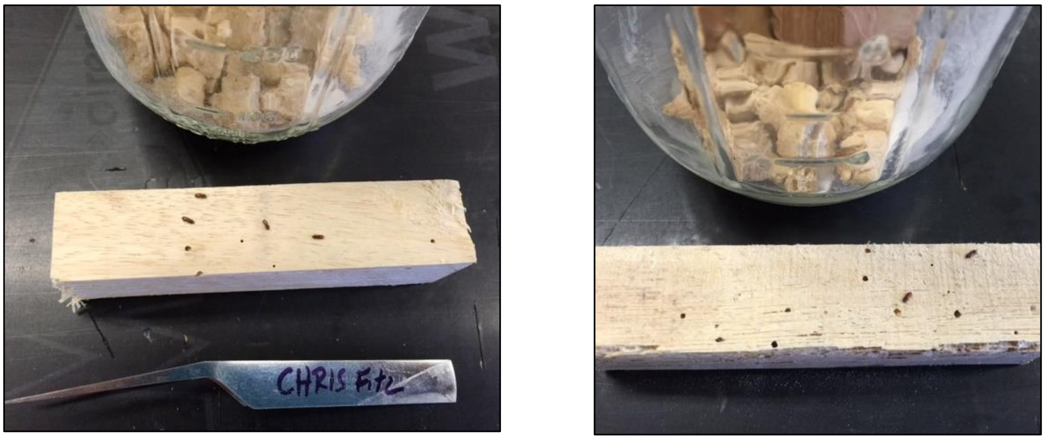

Image 19. Fifteen out of the 20 blackbean control blocks were infested with Lyctus brunneus.

Image 20. Destructive sampling of a blackbean control block uncovered larval galleries packed with fine powdery frass.

Adult beetles were observed crawling over some of the cocowood blocks during the exposure period (Image 21), however no cocowood blocks had any evidence of lyctid infestation (Image 22).

Image 21 Lyctid beetles crawling over a cocowood block however no infestation resulted.

Image 22. None of the cocowood blocks showed any evidence of lyctid beetle infestation.

3.3 Exposure trial 3: *Lyctus* sp. (lyctid beetle)

A short time after the trial was established, adult lyctid beetles were observed walking over some of the cocowood blocks (Image 23). This continued to be observed throughout the duration of the trial, however, all 25 cocowood blocks returned to DAF failed to contain any evidence of lyctid beetle infestation at the end of the exposure period (Image 24).

Image 23. Lyctid beetles crawled over the cocowood blocks during the trial however no infestation resulted.

Image 24. Example of cocowood blocks with no signs of lyctid infestation.

Three out of the five blackbean control blocks had adult beetle emergence holes accompanied by a powdery frass indicating an active infestation (Image 25). Active infestation in the blackbean sections at the trial completion confirmed a strong viable colony was active for the duration of the trial.

Image 25. Example of a blackbean control block infested with lyctid beetles.

3.4 Exposure trial 4: *Dinoderus minutus* (bamboo borer)

During the exposure period, no evidence of any bamboo borer infestation was identified on the cocowood blocks. Bamboo borer activity continued within the already infested bamboo rings and limited bamboo borer infestation occurred in the freshly prepared bamboo rings.

3.5 Exposure trial 5: *Dinoderus minutus* (bamboo borer)

No bamboo borer infestation was recorded for any of the cocowood blocks. Bamboo borer activity remained within the bamboo rings throughout the exposure period and internal sample analysis confirmed the presence of fresh larval galleries and live adults at the end of the exposure period (Image 26). At the time of reporting, no evidence exists externally of any bamboo borer infestation in the cocowood blocks contained within the additional cages.

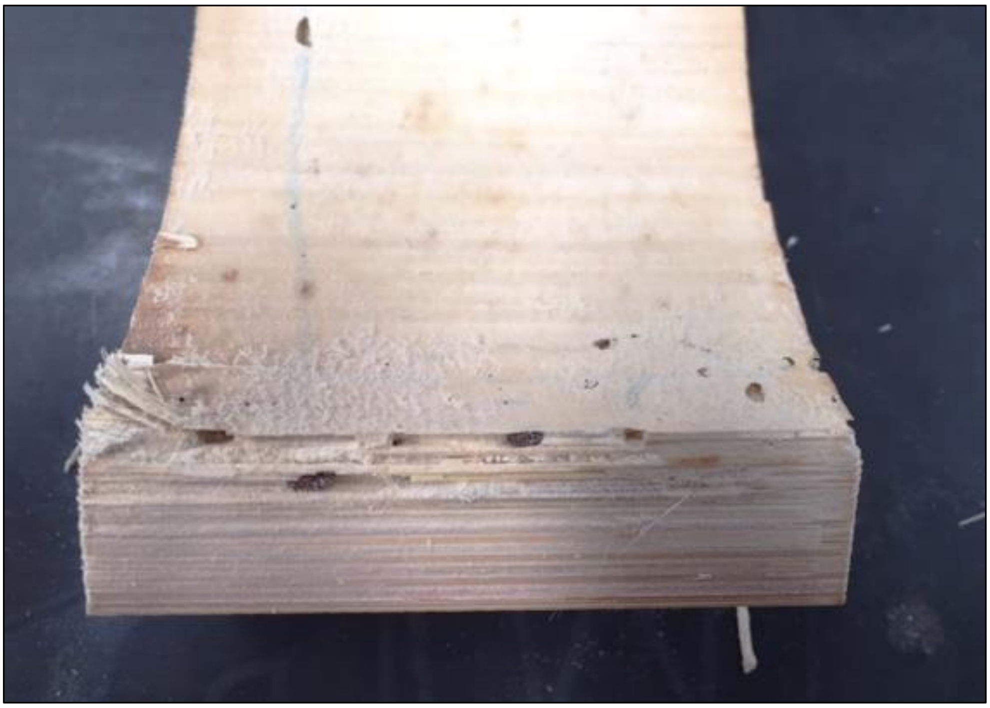

Image 26. Fresh larval galleries and live adults confirming active infestation in bamboo rings at the completion of the exposure period.

4 Discussion

The exposure trials were designed and implemented to provide information regarding the potential susceptibility of cocowood to lyctid beetles and bamboo borers. Five exposure trials were established, three focusing on lyctid beetles and two focusing on bamboo borers. The exposure trials included exposure to ‘wild’ colonies as well as contained colonies of both insect groups.

Of the 120 cocowood blocks that were exposed targeting lyctid beetle attack, no blocks sustained any infestation. Based on the results of exposure trials one to three, the likelihood of cocowood, regardless of the density, being susceptible to lyctid beetle is considered very low.

Similarly, of the 100 cocowood blocks that were exposed targeting bamboo borer attack, none were infested. Based on the results of exposure trials four and five, the likelihood of cocowood, regardless of the density, being susceptible to bamboo borers is also considered to be very low.

The results of these trials provide confidence that wood from the coconut palm stems can be used for the manufacture of wood-based products without the need for any additional processing requirements (e.g. chemical treatment) to be protected from infestation by lyctid beetles or bamboo borers.

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