**Light trapping as a potential tool for *Arhopalus ferus* (Coleoptera: Cerambycidae) control at wood processing facilities.**

**by**

## Steve Pawson, Michael Watt and Eckehard Brockerhoff

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# Commercial in Confidence

Client Report No. 12412 Sydney Number 41382

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| **Contract No:** | TAG/06-07/001 |



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CLIENT REPORT No: Sydney

# EXECUTIVE SUMMARY


## Objective

The objective of this research was to trial the efficacy of light traps of different wave lengths for the control of *Arhopalus ferus* at wood processing facilities. The overall aim is to facilitate the reduction and eventual elimination of export timber fumigation with methyl bromide (MB).

## Key Results

- Of the six light treatments trialled pure UV lamps (UV-BLB) were most efficient at trapping *A. ferus*, average trap catch of 122 individuals night$^{-1}$.
- Yellow light traps caught an order of magnitude less *A. ferus* than either UV lamp (UB-BLB & UV-BL) and averaged 8 individuals night$^{-1}$.
- *A. ferus* numbers in traditional white lights exceeded those in yellow lights by 482%.
- Bark beetle taxa were collected in light traps, however there was little evidence for an effect of light wave length on capture rates.
- The two UV light traps caught significantly higher quantities of non-target insects than all other light sources. However, UV-BLB lights caught significantly few non-target insects than UV-BL lamps.
- Light traps were more efficient at catching *A. ferus* than baited or unbaited Lindgren funnel traps.
- Base line recording was also undertaken of the non-target by-catch from Windsor Engineering's commercial scale UV-BL light traps at the SCA mill Kawarau.

## Application of Results

Manipulation of existing lighting at wood processing facilities could reduce site attractiveness to *A. ferus* dispersing from surrounding environments. Reduced beetle density at the site would then result in fewer beetles in wood stacks leaving the mill. Strategic placement of UV light traps around wood processing facilities could eliminate some of the remaining *A. ferus* attracted to the site.

## Further Work

This trial is based on low intensity light traps of limited power. The next phase is to test changes in light management practices at the site scale in combination with commercial scale UV-BLB light traps.

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Information for Ensis abstracting:

| | |
|---|---|
| Contract number | TAG/06-07/001 |
| Products investigated | Light traps, Lindgren funnel traps |
| Wood species worked on | N/A |
| Other materials used | Arhopalus ferus |
| Location | Eves Valley Sawmill, Nelson |

# INTRODUCTION

Originally from the Western Palaearctic *Arhopalus ferus* (Mulsant)[1] was first recorded in New Zealand north of Auckland in 1963, although it is thought to have been present since the mid 1950s (Hosking & Bain, 1977). *Arhopalus ferus* spread rapidly throughout New Zealand in the first decade post-establishment (Hosking & Bain, 1977), and it is now present throughout New Zealand, where suitable host plants occur (Brockerhoff *et al.*, 2006).

*Arhopalus ferus* attacks freshly felled or disturbed pines (*Pinus* spp.) and are strongly attracted to the odour of burnt pine (Suckling *et al.*, 2001) and other host volatiles such as α- pinene and ethanol (Brockerhoff *et al.*, 2006). Adult beetles emerge from November to March (Brockerhoff & Hosking, 2001) and are most active between dusk and midnight (Suckling *et al.*, 2001).

Although there is no evidence that *A. ferus* damages, or oviposit on, freshly sawn timber, the adult behaviour of utilising timber packets and stacked logs as day-time refugia is a serious export quarantine risk (Hosking, 1970; Hosking & Bain, 1977). To comply with Forest Product Import and Export Regulations fumigation or other acceptable treatments are required prior to export (Hosking, 1970). The traditional practice in New Zealand has been to fumigate with methyl-bromide during *A. ferus* flight periods, as trialled by Ray (1972).

New Zealand's ratification of the Vienna Convention and Montreal Protocol on substances that deplete the ozone layer commits to a phase-out of Methyl-Bromide by 2005, except for quarantine and pre-shipment applications and critical uses. The New Zealand government will not support any of the existing critical use applications from 2008 (Anon, 2006). Methyl bromide use as a timber fumigant is currently permissible, however environmental concerns and significant public opposition as a hazard to public health (Lewis, 2005) may see this change in the near future. The forest industry is currently evaluating a range of options for reducing or eliminating the need for Methyl-Bromide fumigation including heat treatment, alternative fumigants, chemical lures and light trapping.

[1]Historically *A. ferus* has been erroneously referred to as *A. tristis* in many New Zealand publications.

*A. ferus* is strongly attracted to artificial light at night (Wang & Leschen, 2003). As such, Light traps have been used to monitor *A. ferus* flight periods and subsequently determine the fumigation requirements of export timber. However, the relative attraction of *A. ferus* to different portions of the light spectra is unknown. Ultra-violet light traps have proven successful at catching *A. ferus* at a paper factor in Whakatane, New Zealand (Gordon Hosking pers. comm.. 2007). Although, large quantities of non-target native insect species (from now on referred to as by-catch) are also caught.  Information on the relative attraction of *A. ferus* to different coloured lights is an important first step in attempting to reduce this by-catch.

In New Zealand host volatiles, e.g., α-pinene, have been used as chemical lures to monitor the presence of a range of bark beetle (Scolytinae) and wood boring taxa, including *Hylurgus ligniperda, Hylastes ater*, *Prionoplus reticularis* and *A. ferus* (Brockerhoff *et al.*, 2006). The aim of the nationwide surveillance program was to determine the abundance of native and established taxa and act as an early warning system to identify new incursions of other exotic species (Brockerhoff *et al.*, 2006). As yet chemical lures have only been used as a monitoring tool and their potential as a control method is unknown.

This study tests the relative attraction of *A. ferus* to different wave lengths of light given a high background level of host plant volatiles produced by the kiln drying of wood. In a separate experiment, we also trialled a range of chemical lures to determine the relative attraction of *A. ferus* and the bark beetle taxa to host volatile baited Lindgren funnel and light traps. We also assess the level of by-catch associated with different light treatments and provide management recommendations to reduce insect abundance at wood processing facilities.

# MATERIALS AND METHODS

## Study Site

The study was undertaken at the Eves Valley Sawmill (Carter Holt Harvey) Nelson, 41° 20’48”S, 173° 05’16”E, 71 m.a.s.l. The mill produces large amounts of attractive volatiles from its eight wood drying kilns that are powered by burnt wood waste and has a distinctive light signature in the valley. Eves Valley Mill was chosen as it had the highest reported abundance of *A. ferus* in the nationwide survey of wood boring and bark beetles by Brockerhoff et al. (2006).

## Trapping Protocol

Light traps consisted of a wooden frame that supported a fluorescent tube (Figure 1). Side panels of white 3mm corflute plastic were used to intercept flying beetles that then fell into the square plastic water filled container beneath. A few drops of standard liquid detergent were used to reduce surface water tension. The fluorescent tubes were of two different lengths, 1.2 m and 0.91 m. The corflute plastic side panels on traps with the 1.2 m tubes was truncated at the 0.91 m mark and a section of cardboard tube was used to enclose the upper exposed portion of the fluorescent tube. This was done to create fluorescent tubes of equivalent length and light intensity between light treatments. Six different types of light were tested, yellow, red, green, white, black light and black light blue. Specifications of the different light treatments are given in Table 1.

Two replicates of the six light treatments were established around the wood drying kilns at the Eves Valley mill for a period of 6 nights during mid-summer, 14-19$^{th}$ February, 2007. Each light was placed such that individual light traps were not visible to each other to avoid conflicts of spectra. Lights were randomly rearranged each night to account for potential site effects. Each morning the abundance of *A. ferus*, *Hylastes ater*, *Hylurgus ligniperda* and *Prionoplus reticularis* were recorded and any additional insects were collected

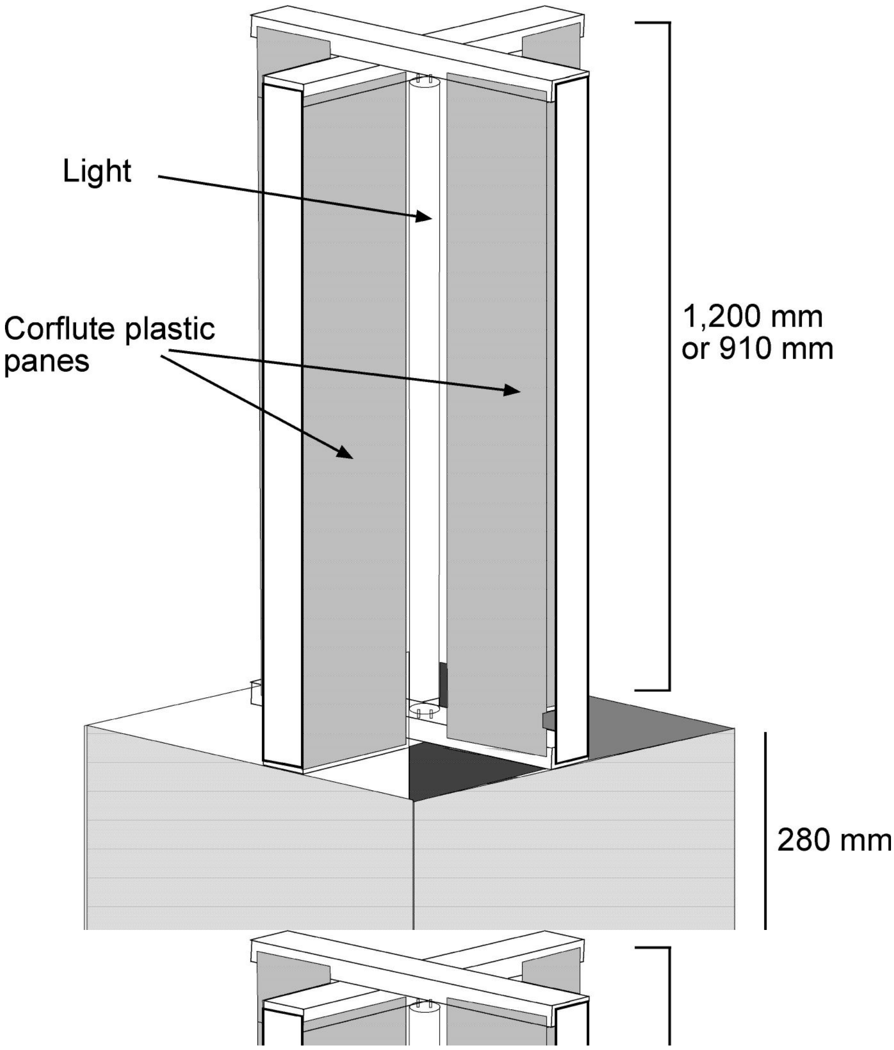

Figure 1. Light trap design.

Table 1. Spectral composition of the fluorescent tubes used in the six different light treatments.

| Light Type | Manufacturer | Model |
|---|---|---|
| BLB | NEC | FL30BL-B |
| BL | NEC | FL30SSBL-36 |
| Green | Osram | L36W/66 |
| Yellow | Osram | L36W/62 |
| Red | Osram | L36W/60 |
| White | Sylvania | Luxline Plus F30W860 |

and stored prior to a dry weight assessment. Dry weights were calculated after samples had been oven dried at 80 °C for 24 hours.
Four replicates of Lindgren funnel traps were placed in different areas of the mill for a three week period between the 14th February and the 6th March, 2007. The treatments were; 1) an unbaited control, 2) α-pinene (95% minus enantiomer, release rate ca. 2 g per day at 20 °C) plus ethanol (release rate ca. 30 mg per day at 20 °C) produced by Pherotech, Delta, BC, Canada. The α-pinene + ETOH lure was chosen as it is a standard pheromone used to monitor wood boring and bark beetles (Brockerhoff et al. 2006). Trap catches were then recorded weekly over a period of three weeks. Treatments were rotated randomly each week within each replicate to reduce potential site effects. All catch data presented has been expressed as an average catch per night to allow comparison with data from the light traps.

### Analyses

Trap catch data from the light traps was analysed separately from the catch data obtained from the pheromone traps. All analyses were undertaken using SAS (SAS Institute, 1996). Variables were tested for normality and homogeneity of variance and transformations were made as necessary to meet these underlying statistical assumptions. The main and interactive effects of time and treatment on trap catch data for the four beetle species and the bycatch were tested using a mixed effects model.

## RESULTS

### Light traps

A total of 2,976 *A. ferus*, 407 *H. ligniperda*, 244 *H. ater* and 47 *P. reticularis* were recorded over the six night trapping period. By-catch of all other insects, which was dominated by Lepidoptera, varied between 0.002g and 6.78g.

*Arhopalus ferus* catch differed significantly between light treatments (Table 2). Yellow light had significantly lower trap catches than all other light treatments (Figure 2), averaging eight individuals per night. Trap catches from green, red and white light traps exceeded catches from the yellow traps by 192%, 230% and 482%, respectively. Trap catch in the two UV light treatments, black light and black light blue, was highest of all lights tested (100 and 122 individuals night$^{-1}$, respectively) exceeding trap catch for yellow light by over an order of magnitude. Trap catch from the black light blue treatment was significantly higher that of all other lights ($P$<0.05), apart from black light. The trap catch for black light significantly exceeded that of all other lights ($P$<0.01) apart from black light blue ($P$= 0.4) and red light ($P$= 0.14).

*Hylurgus ligniperda* was the only bark beetle monitored that showed significant differences between light treatments (Table 2). This was primarily due to a significant interaction (F = 9.13, $P$<0.001) between light treatment and trap night.  Analysis of this interaction revealed that the abundance of *H. ligniperda* was significantly greater in black light traps compared to other light treatments (Figure 3), but only on nights 4 (F = 40.74, $P$<0.001) and 6 (F = 9.44, $P$<0.001) of the trial. *Prionoplus reticularis* was present in low abundances in all treatments except yellow light (Figure 3). Due to the low trap captures this species will not be discussed further.

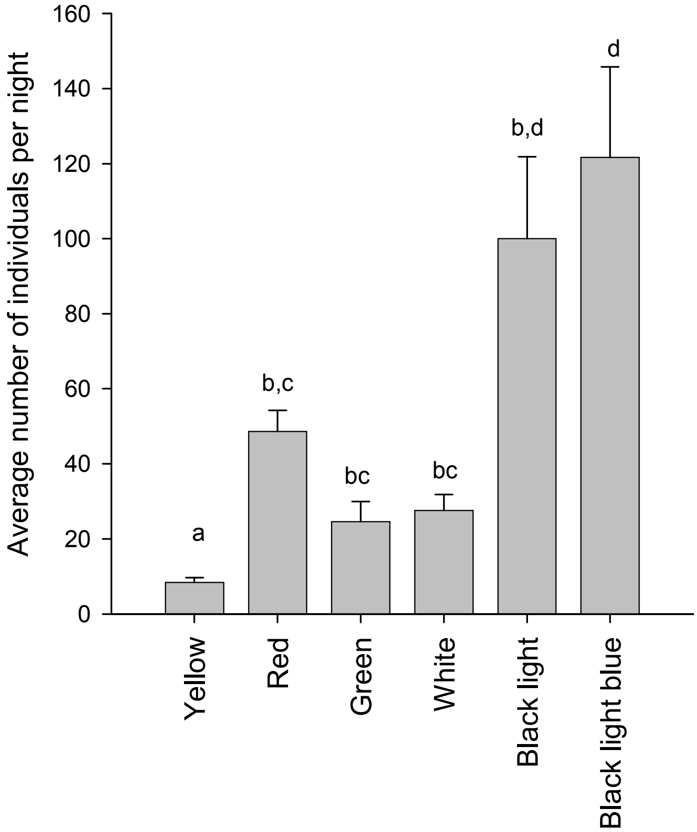


Figure 2. Abundance of *Arhopalus ferus* by light treatment. Each value shown in the mean ± standard error

Table 2. Main and interactive effects of light treatment and night on insect abundance. Values presented are F- values followed by *P* values in brackets.

| Species | Light (L) | Trap night (N) | L*N |
|---|---|---|---|
| *Arhopalus ferus* | 16.59 (0.002) | 0.86 (0.537) | 0.96 (0.556) |
| *Hylastes ater* | 3.38 (0.085) | 1.33 (0.316) | 1.03 (0.504) |
| *Hylurgus ligniperda* | 9.71 (0.008) | 14.37 (<0.001) | 9.13 (<0.001) |
| *Prionoplus reticularis* | 1.24 (0.395) | 0.14 (0.979) | 0.66 (0.817) |
| By-catch | 23.02 (<0.001) | 11.95 (<0.001) | 1.80 (0.144) |

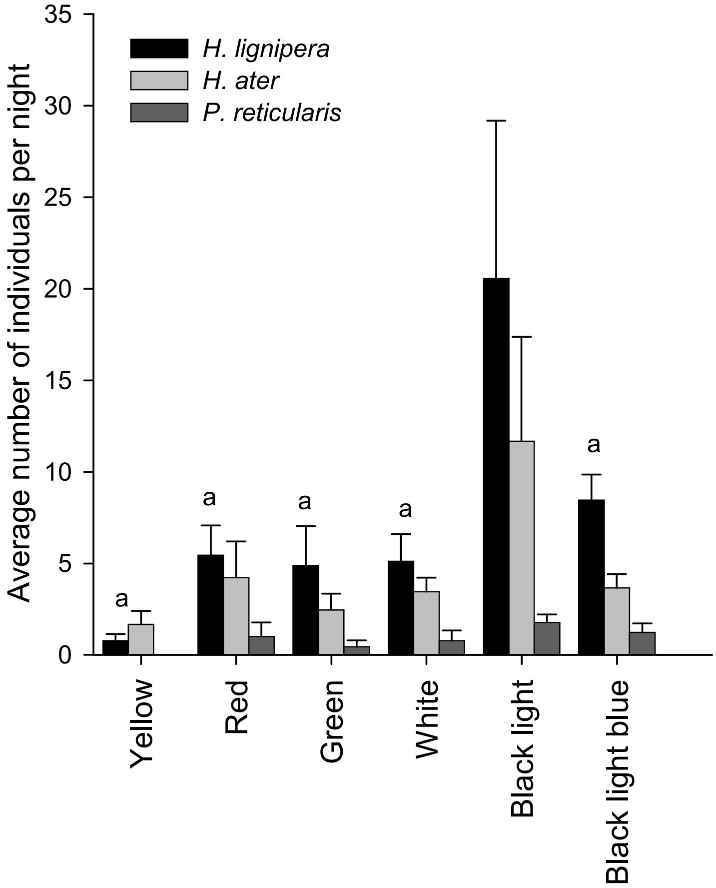


Figure 3. Abundance by light treatment of *Hylurgus ligniperda* (black bars), *Hylastes ater* (white bars), and *Prionoplus reticularis* (grey bars). Each value shown in the mean ± standard error.

The quantity of insect by-catch varied significantly (F=23.0, $P<0.001$) between light treatments (Table 2). By-catch was greatest in the two UV light trap treatments, in which total catch averaged 2.85 and 2.05 grams night$^{-1}$ respectively, for the black light, and black blue light. An intermediate level of catch was recorded for the green (0.89 grams night$^{-1}$) and white lights (0.64 grams night$^{-1}$), while the lowest catch occurred for the red (0.42 grams night$^{-1}$) and yellow lights (0.41 grams night$^{-1}$). Trap catch between the two UV lights significantly differed ($P<0.05$) and significantly exceeded that of all other light treatments ($P<0.05$). Trap catch from green light significantly exceeded that of catch from red ($P<0.05$) and yellow lights ($P<0.05$).

By-catch also varied significantly with trap night due to the high catch of insects on night two. However, as catch was higher for all light treatments, on this night, there was no significant treatment by trap night interaction effect (Table 2).

## Pheromone traps

A total of 1,193 *A. ferus*, 196 *H. ligniperda*, 77 *H. ater* and 1 *P. reticularis* were caught by the Lindgren funnel traps over the three week period. By-catch in the Lindgren funnel traps was almost non-existent and subsequently was not recorded.

Pheromone treatment did not significantly influence trap capture (Figure 4, Table 3). Despite this, average catch of *A. ferus* in the α- pinene and ethanol traps exceeded those of the control by 67% (Figure 4, Table 3). Trap catch of *H. ligniperda* differed significantly between date, with a weak interaction between treatment and date for *H. ater* (Table 3). Exploration of this interaction indicated that *H. ater* was more abundant during the second sampling period ($F = 6.69$, $P<0.002$).

Comparison of data from the two experiments indicated that lights were more effective than pheromones for trapping insects (Figs. 3 and 6). Trap catches of *A. ferus* using the UV lights exceeded that of the most effective pheromone, α- and β-pinene and ethanol, by over ten-fold (121 and 100 *vs.* 8.33 individuals night$^{-1}$).

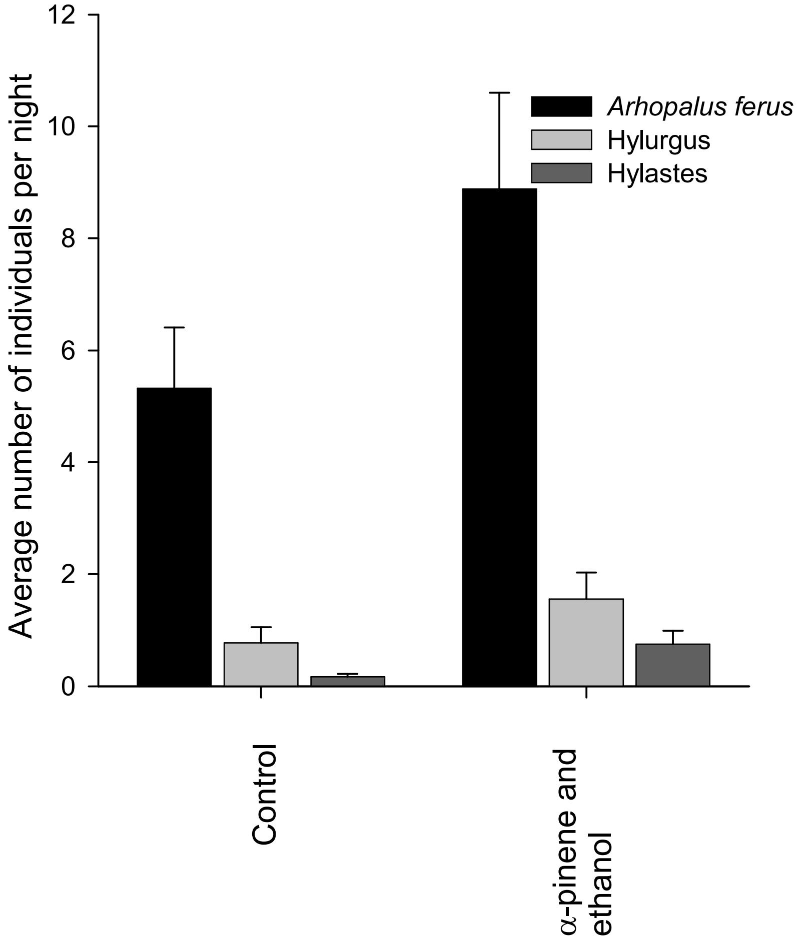


Figure 4. Abundance by pheromone treatment of *Arhopalus ferus* (black bars), *Hylurgus ligniperda* (white bars), *Hylastes ater* (grey bars). Each value shown in the mean ± standard error.

Table 3. Main and interactive effects of chemical attractant and night on insect abundance. Values presented are F- values followed by P values in brackets.

| Species | Chemical (C) | Trap night (N) | C*N |
|---|---|---|---|
| *Arhopalus ferus* | 1.69(0.242) | 0.12 (0.888) | 0.35(0.713) |
| *Hylastes ater* | 2.74 (0.149) | 1.43 (0.277) | 6.73 (0.011) |
| *Hylurgus ligniperda* | 1.44 (0.276) | 8.61(<0.005) | 0.78 (0.465) |

# Discussion

## Light traps for beetle control at wood processing facilities

Light trapping was the most effective method for trapping *A. ferus*, despite the presence of competing alternative stimuli, such as host volatiles emitted from a wood processing plant. Lindgren funnel traps, that mimic host trees, caught *A. ferus*, however trap catches were an order of magnitude lower than the most effective light trap treatments (Figures 3 & 6). The high trap catch of *A. ferus* in the two UV and green light treatments (Figure 2) is consistent with the known UV-blue-green spectral sensitivity of the insect photoreceptors (Briscoe & Chittka, 2001). Attempts at controlling *A. ferus* populations at wood processing facilities with light traps should concentrate on ultraviolet light, as most insects have enhanced sensitivity to this portion of the spectra compared with the blue or green regions (Menzel, 1975). Unfortunately, the relatively uniform spectral sensitivity of insect taxa (Briscoe & Chittka, 2001) results in a concurrently high level of non-target species by-catch in UV light traps (Figure 4). By-catch is a statement largely utilised in marine ecosystems, however there is potential for significant non-target by-catch if powerful UV light traps are implemented on a commercial scale (Pawson, unpublished data).

*A. ferus* exhibited a weak field response to red-light, which is atypical in Coleoptera (Figure 2). In rare instances Coleoptera are known to be sensitive to portions of the red spectrum (Briscoe & Chittka, 2001), and to longer infra-red wavelengths via specialised sensory meta-thoracic pit organs, e.g., *Melanophila acuminata* (Schmitz & Bleckmann, 1998). *Arhopalus ferus* is also attracted to burnt pine (Suckling *et al.*, 2001), like *M. acuminata* (Schmitz & Bleckmann, 1998) and further exploration of the sensitivity of *A. ferus* to red and infrared wavelengths in combination with burnt pine odours may identify other control options. The potential advantage of manipulating the red spectral response of *A. ferus* would be a reduction in by-catch of non-target species.

There was little difference in the response of bark beetle taxa (*H. ater* and *H. ligniperda*) to different light treatments. There is some evidence that *H.*

*lignipera* responds to black light traps, however this was confounded by a light treatment by trap night interaction effect, with high catches in this light treatment on two nights of the study. Results to date suggest that light trapping will be an ineffectual way to reduce population so bark beetles at wood processing sites. However, light traps should provide a means of assessing flight periods of these species.

### Effectiveness of Lindgren funnel traps

Lindgren funnel traps baited with chemical lures had consistently greater trap catches of *A. ferus*. Although this increase was not statistically significant, a 67% increase is biologically significant and consistent with the results of Brockerhoff et al. (2006). Brockerhoff et al. (2006) reported that α-pinene was the most attractive to *A. ferus* in a nationwide survey. The high background levels of host volatiles produced at timber processing facilities, such as Eves Valley, may have masked the influence of chemical lures and reduced their effectiveness. However, from a population control perspective light traps clearly have the greatest potential as a control method for *A. ferus* at wood processing sites

## RECOMMENDATIONS

The combination of host volatiles and high intensity commercial lighting can result in large populations of *A. ferus* at wood processing facilities, such as Eves Valley sawmill. We suggest that the future of site specific *A. ferus* control to reduce the reliance on methyl-bromide fumigation will require an integrated approach. Critical to success will be a reduction in the overall attractiveness of wood processing facilities to *A. ferus* from surrounding habitat. Yellow light is least attractive to *A. ferus*, and insects in general. A shift to low intensity yellow lights for general site lighting would decrease the number of incoming insects to the site. Unfortunately, this will not entirely eliminate *A. ferus* from the site due to the attraction of host volatiles produced in the kiln drying of wood and wood-waste fuel burning. Strategic positioning of UV light traps could then be used to trap remaining individuals that are attracted site, particularly in areas where export timber stacks are stored. Black light blue fluorescent tubes do not emit any visible blue light, which is known to be attractive to some insect groups (Briscoe & Chittka, 2001). As such, black light blue light sources should be used as there is weak support from our data for lower by-catch of non-target species from these lights. Furthermore, by-catch of non-target taxa should already be minimised by reducing the quantity of incoming insects to the site by utilising low intensity yellow lights.

The second phase of these trials in 2007/2008 will concentrate on attempting a site level application of these results to determine the effectiveness of light traps for *A. ferus* control at larger scales.

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# APPENDICES

## *Appendix A – Preliminary quantification of by-catch from Windsor Engineering commercial scale UV-Light traps.*

In addition to the field assessment of light wavelength attractiveness to *Arhopalus*, a small trial was initiated to collect base line data on the insect by-catch attracted to Windsor Engineering's UV light traps. These traps are currently in commercial use at the SCA tissue mill in Kawarua. The existing UV light traps were modified by suspending plastic containers (Length X Width X Height, 163, 102, 85 mm) over the larger collecting trough to obtain a quantitative measure of *Arhopalus* catch and its associated by-catch. Two traps were suspended across the UV-light trap trough level with the top. Each trap was placed at 1/3 of the length of the trough. Unfortunately the project was initiated too late to monitor the main flight period of *Arhopalus*. David Whyte of Genera who regularly services the UV-light traps and roughly monitors total insect catch informed us that we were probably about 2 weeks light with our sampling.

Average catch of *Arhopalus* in each week over the three week trapping period was 2, 1.3 and 1.2 individuals per trap per week. Average by-catch, as a dry weight measure, was 0.9, 1.0 and 0.7 grams per trap per week. It is anticipated that the *Arhopalus* catch will be significantly higher than this at certain times based on what we know of abundance during peak flight period times.

A second small sub-sample of the total catch in the main UV trap trough was taken on 22 January 2007 to provide base line measures of the most common groups of arthropods attracted to the UV Light traps. Lepidoptera (moths) were the most common insect caught (Table 4), although they could not be identified to species due to the condition of the specimens. The abundance of moths is consistent with their known attraction to artificial light. Surprisingly large numbers of the eucalypt pest *Paropsis* were attracted to the lights traps (Table 4). There were a number of aquatic taxa present, e.g., Ephemeroptera and Trichoptera, due to the proximity to the Kawarau river next to the SCA mill.

Table 4. Taxonomic breakdown of a 70 gram wet weight sample of insects collected by sieving material caught by the Windsor Enginerring UV-Light traps at SCA mill Kawarau on the 22 January 2007.

| Taxonomic Group | Count | Comments |
|---|---|---|
| Coleoptera (general) | 17 | |
| *Hylurgus* | 5 | |
| *Hylastes* | 5 | |
| *Arophalus* | 10 | |
| *Paropsis* | 82 | |
| Cerambycidae | 12 | |
| Elateridae | 67 | |
| Carabidae | 5 | |
| Dytiscidae | 13 | |
| Tenebrionidae | 2 | |
| Scarabaeidae | 50 | |
| Diptera | 56 | |
| Lepidoptera | 257 | |
| Hymenopera | 14 | Mainly Vespulidae |
| Hemiptera (general) | 8 | |
| Cicadidae | 6 | |
| Ephemeroptera | 1 | |
| Trichoptera | 4 | |
| Orthoptera | 4 | |

The pilot trial proved the suitability of this method for quantifying by-catch and will be trialled more extensively in the 2007-2008 trapping season. Weekly trap changes, as done in the 2006-2007 season, were too long to allow species level identification of by-catch. They are adequate for a dry weight sample measure, however insects left in suspension for a week were no longer in a suitable condition for species identification. Future sampling will involve a more intensive daily collection of trap material that will allow species level identification.