PHOSPHINE AS A FUMIGANT TO CONTROL *HYLASTES ATER* AND *ARHOPALUS FERUS*, PESTS OF EXPORT LOGS

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ABSTRACT

The black pine bark beetle (*Hylastes ater)* and the burnt pine longhorn beetle *(Arhopalus ferus)* are major insect pests of *Pinus radiata* in New Zealand and are currently listed as undesirable on imported *P. radiata* logs from New Zealand by AQISQ, the Chinese quarantine authorities. Any discoveries of these pests could endanger one of the most important export markets for New Zealand logs. Experiments were carried out to examine the efficacy of the non ozone-depleting fumigant phosphine for eliminating these two pests from *P. radiata* logs at egg, larva and adult life stages. Direct exposure to phosphine at levels as low as 200 ppm for up to 10 days has disinfested the three life stages of both pests. Phosphine has the potential to control both pests in export logs before they arrive in the other countries and may be a replacement fumigant for the ozone-depleting methyl bromide.

Keywords: Phosphine, in-transit fumigation, export logs, methyl bromide replacement.

INTRODUCTION

The black pine bark beetle, *Hylastes ater* (Paykull) (Coleoptera: Scolytidae), is of European origin but is now found throughout New Zealand wherever exotic forests occur. *Arhopalus ferus (=Arhopalus tristis)* (Mulsant) (Coleoptera:Gerambycidae), the burnt pine longhorn beetle, is also European and was accidentally introduced into New Zealand in the mid 1950s. It is present throughout the North Island and has been recorded from the South Island's West Coast. Both insects are listed as undesirable on imported *Pinus radiata* logs by Chinese Authorities.

China is New Zealand's third largest and fastest growing market for *P. radiata* logs. In response to restrictions on methyl bromide use, Chinese quarantine authorities (AQSIQ) have agreed on the use of the non ozone-depleting fumigant phosphine for in-transit treatment of logs in sealed shipping holds rather than fumigation with methyl bromide on arrival in China. The protocol stipulates that a phosphine concentration of 200 ppm is maintained for 10 days.

Phosphine has been used extensively and successfully as a fumigant in the grain industry to counter infestations of live insects and their eggs (Annis 2000; Williams & Ryan 2000) and has been experimentally tested in some fresh produce. However, when used for in-transit fumigation of logs on ships, technical and practical issues have arisen. It has been reported that Chinese inspectors have found live insects in pine logs that have been fumigated with phosphine (M. Goss, pers. comm.). Such discoveries endanger one of the most important export markets for New Zealand logs. High relative humidity inside the holds and the absorbance of phosphine by logs are factors that may lower the concentration of phosphine and reduce its efficacy. Investigation of these issues is important to ensure successful and cost-effective log fumigation and establish minimum phosphine concentrations for in-transit fumigation.

New Zealand Plant Protection 57:257-259 (2004)

This study aimed to validate the protocol currently used for fumigating New Zealand export *P. radiata* logs in-transit to China with phosphine.

MATERIALS AND METHODS

Trials were conducted using *H. ater* adults and larva and *A. ferus* adults and eggs. The insects were supplied by Frontline Biosecurity Ltd and sent to the Food Industry Science Centre, Palmerston North. Insects of all life stages were kept at 4°C prior to the trials.

For *H. ater* three phosphine concentrations (200, 700 and 2000 ppm), each replicated four times, were compared with a zero concentration control, for which there were only three replicates. This experiment was carried out twice.

Arhopalus ferus adults were treated with two phosphine concentrations (700 and 2000 ppm), replicated four times, which were compared with a control treatment (three replicates). *Arhopalus ferus* eggs were treated with two phosphine concentrations (100 and 200 ppm) and compared to an untreated control. There were four replicates of the phosphine treatments and the control.

Adult and larvae fumigation trials were carried out in 92 litre stainless steel fumigation chambers. Insects were put on to bark covered *P. radiata* chips inside plastic 60 ml containers with mesh covered ventilation holes. The containers were placed inside the chambers and left for ten days. Each container held between 9 and 12 adult beetles or larvae, depending on the numbers of insects available at the time of the trial. Trials were carried out at 15-18ºC. The number of surviving insects was assessed 24 hours after the end of the exposure period.

Hylastes ater larvae in the untreated control did not survive the first 10-day trial. It is thought that this was due to dehydration or starvation. For the second run the larvae were placed on chips of *P. radiata* wrapped in moistened tissue paper and good survival rates in the controls were obtained. Survival of *H. ater* adults was good in both experiments with the beetles being well established under the bark of the chips.

Arhopalus ferus eggs (100±5) were placed in Petri dishes and then placed in 1 litre glass jars with septa through which phosphine gas was injected. The treated eggs remained in the jars for 10 days and were then moved to a insect rearing room (at 20°C) to hatch. Treatment efficacy was assessed two weeks after fumigation by counting the number of eggs hatching.

RESULTS

Survival of both insects and all life stages was high (73–88%) (Tables 1 & 2) for all control treatments, except for the first experiment using *H. ater* larvae where they all died. The mean percentage of *A. ferus* eggs hatching in the control treatment was also high (Table 2).

All phosphine treatments gave 100% control of both insects at all life stages (Tables 1 & 2).

The phosphine concentrations within the experimental chambers declined by less than 10% over the duration of the trials.

DISCUSSION

In stored product fumigations, the minimum phosphine dosage regimes required to achieve a very high level of kill in almost all stored-product beetles (other than *Trogoderma spp.*), psocids and moths, excluding known resistant strains, are 10,000 ppm for 1.5 days, 1200 ppm for 2 days, 1000 ppm for 8 days, 200 ppm for 10 days, 35 ppm for 20 days and 10 ppm for 30 days (Annis 2000). However, these regimes are defined for a dry commodity and phosphine residue is a concern.

Green logs in ship holds can absorb phosphine and therefore change the concentration of phosphine in the air in the hold. Maintaining an effective phosphine level in ship holds in which logs are transported is crucial to successful fumigation. Therefore, it is very important to determine the minimum concentration of phosphine and the length of exposure required for 100% mortality of pests and thus ensure a successful cost-effective fumigation procedure.

TABLE 1: Mortality (%) of *Hylastes ater* adults and larvae after exposure to various phosphine concentrations for 10 days. Values are the mean of 4 replicates with the SEM shown in parentheses for the control treatment (n=3).

	Experiment 1	Experiment 2	
Phosphine (ppm)	Adults	Adults	Larvae
0	13 (3)	25 (7)	12 (6)
200	100	100	100
700	100	100	100
2000	100	100	100

TABLE 2: Mortality (%) of *Arhopalus ferus* adults and hatch (%) of *A. ferus* eggs after 10 days of exposure to various phosphine concentrations. Values are the mean of 4 replicates with the SEM shown in parentheses for the control treatment.

Phosphine (ppm)	Adults	Eggs
0	27 (3)	97 (2)
100	-	0
200	-	0
700	100	-
2000	100	-

Mortality rates for all insect stages of both species tested were 100% at each of the phosphine concentrations. These results suggest that phosphine fumigation may be an effective method for disinfesting export log pests, providing the minimum phosphine level of 200 ppm is maintained during the fumigation period of 10 days. Further investigation is required to determine how best this concentration can be maintained over that period and also to determine whether other concentrations and shorter exposure periods can also effect control of these and other pests. Factors that affect the absorption of gaseous phosphine by logs during in-transit fumigation, such as high relative humidity and condensation, should also be investigated to ensure the minimum concentration requirement is to be maintained.

ACKNOWLEDGEMENTS

Our thanks go to Mr Wen Lu for his help with insect efficacy assessments, and his ideas for maintaining insect viability during fumigation.

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