AERIAL SPRAYING AGAINST THE PAINTED APPLE MOTH
Btk Pesticide exposure, spray drift and environmental persistence

INTRODUCTION

The proposed aerial spraying programme against the Painted Apple Moth (PAM), scheduled to commence in late November 2001, has raised a number of issues of community concern.

Reported health effects from the spray, both in Auckland from the 1996/7 White Spotted Tussock Moth (WSTM) eradication programme and overseas, have heightened awareness about possible levels of pesticide exposure. This includes the question of drift, penetration into buildings and homes and environmental persistence.

This report aims to briefly outline what is known about the performance of the spray being used, highlight areas of concern, identify areas for possible research, and suggest ways in which the community can protected itself.

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SUMMARISED CONCLUSIONS

- Spray drift outside the target zone will go much further, and last far longer, than previously recognised.
- Suspended aerosol sizes of active Btk spores are going to be of a finer more respirable size, and remain active for days rather than hours.
- The persistence of viable Btk spores in the environment will be more comprehensive and widespread than previously suggested, with fresh water, seawater and soil compromised from 40 days to two years.
- The penetration of active Btk spores into buildings is going to be far greater and less preventable than previously thought.
- The persistence of viable Btk spores indoors indicates that 'at risk' people might be better off camping outside!
- Recommendations for prudent avoidance are going to need urgent re-examination.
- The severe lack of data and quality studies in all areas of drift, aerosol sizes, building penetration, persistence etc warrants immediate funded attention.

THE SPRAY

The Ministry of Agriculture and Forestry (MAF) is proposing to conduct the aerial spray eradication campaign against the PAM using the insecticide *Bacillus thuringiensis* var. *kurstaki* (Btk) in the commercial formulation Foray 48b.

The spray is a complex chemical mix whose active ingredient is the spores and endotoxins in the protein crystals of the Btk formulation. Nearly 98% of the spray is so-called inert ingredients whose identity is a commercial secret. But they are known to contain

- Thickening and wetting agents
- Appetite stimulants
- Sticking and anti-evaporation agents
- Anti-bacterial and fungal inhibitors, and
- Sunscreens

Note: Foray 48b is the same spray used for both the WSTM campaign and the overseas studies quoted in this report. See the WSTM Environmental Impact Assessment of1996 for a comprehensive summary of Btk.[1] MAF are using this EIA for the PAM campaign.

Aerial Application

Aerial spraying will be by helicopter over targeted areas. Whilst it is almost certain that spraying will be very early morning, strength of the formula, droplet size, flying height and speed etc, won't be known until MAF publish their operational plan. What is known is that wind, humidity, high temperatures and thermal air currents can all hinder the spray reaching the ground target, and therefore increase the likelihood of spray drift.

SPRAY DRIFT

Spray drift is simply the aerosol particles that fall outside the target area. The larger the droplet size the greater the chance it will fall within the spray zone. But fine mist sprays coat the vegetation far more effectively. Therefore the operational aim to maximise coverage also produces the greatest risk of spray drift, with finer particles more vulnerable to wind and thermal air currents.

But a comprehensive study in Vancouver in Spring 1999,[2] highlighted the fact that measurable drift of culturable Btk up to a kilometre away occurred even though large droplet sizes were applied. They noted that the extent of the drift was not anticipated, for the target droplet size should have settled within 5 minutes. Instead fine aerosols were produced during the aerial spraying. Sizes this fine allows them to remain suspended in the air for hours to days and subject to area wind currents. Likely explanations for the break up and size reduction of the droplets related to plane speed, wind speed, humidity and temperature.

INDOOR PENETRATION

The ability of spray drift to move indoors was established in an experimental study during the WSTM campaign.[3] Measurable penetration of Btk spores was recorded in a sampling study of 8 houses during the first aerial spray. The study found that there was considerable variation in the extent of penetration, unrelated to the age of the house or type of joinery.

This has been borne out in the Canadian study above, which found no relationship in the 33 homes studied between indoor Btk concentrations and the type of house, conditions or environment. In addition, simultaneous samples taken outside these study homes, were able to accurately compare the indoor/outdoor concentrations and the movement of the Btk spores between. (The outdoor sampling in the Auckland Study was from a separate site on an open reserve).

The Canadian study found that the pattern of differences between indoor and outdoor exposure was unexpectedly complex. It showed that the highest concentrations of Btk, both inside and out, was at 2 to 3 hours after start of spraying, and tended to be lower during the spray. Whilst concentrations outside fell exponentially after this time, indoor measurements 5-6 hours after spraying were higher than outside. (Where the outdoor concentrations were higher, indoors were as well).

The study suggests that migration of Btk inside took place with the resumption of normal activities. The ability for air to also be drawn into even unoccupied or well sealed buildings as shown in the Auckland study, is borne out by reports mentioned in the Canadian study of passive infiltration by air exchange. These showed complete exchange of indoor air in 2.5 - 14 hours. If indoor Btk does not dissipate as quickly as outdoors as suggested by this study, the question of persistence is important.

PERSISTENCE

The ability of the spray to persist in the environment is a two edged sword. The spray is formulated to ensure the Btk remains active long enough for the caterpillars to eat the coated vegetation and die. But this also means it persists longer in the un-targeted human environment.

The Btk formulation needs to be delivered in optimum concentrations and quantities, and remain long enough to be eaten. Rain can dilute and wash the spray off and sunlight breaks down the active ingredients. Therefore the spray contains sticking and anti-evaporation agents, together with sunscreen to block UV light. There is the possible addition of appetite stimulants. This is because it is known that low doses of Btk can inhibit caterpillar feeding. If they reduce their intake they can recover to eat another day!

The survival of Btk spores in the environment is well documented. The 1996 EIA being used by MAF notes survival for at least 4 months in most types of soil. Persistence in fresh water is recorded from 2 months to 2 years, and 50% survival in

seawater of at least 40 days. There is evidence that even chlorination is not sufficient to kill Btk.

Whilst it is accepted that airborne Btk is rapidly inactivated by UV light, results from the Canadian study show that culturable spores were still detectable up to the end of the nine days sampled after the spray. Overall they suggest a half-time of 2.4 days. UV resistant spores would account for the longer persistence in the air, together with surface deposited spray drying out over time and resistant spores being released back into the air by the wind.

Concentration of indoor Btk spores does not seem to have been measured in any study beyond the 6 hours in Vancouver. But this study showed that while outdoor concentrations decreased rapidly with a half time of 3.3 hours, indoor concentrations fell much slower. Five to six hours after spraying commenced, Btk concentrations indoors were far higher than outside.

The researchers suggest that aerosols infiltrating homes may be the smallest ones and therefore take much longer to settle out of the air. They also note that there is little UV light indoors capable of killing the Btk spores. This lack of data on Btk spore survival indoors is a concern, for with outdoor survival rates of days if not weeks in the harshest environment, the probability of viable spores persisting indoors for far longer is very real.

RESEARCH

> *"Few published studies have examined human health outcomes or Btk exposure levels associated with spray programs. Thus, although Btk is a member of a new generation of highly specific biological pesticides expected to have few human health consequences, members of the public remain concerned."* [2]

The Vancouver study is the result of the setting up of a Human Health Surveillance Committee in response to community concerns about Btk Spray programmes. The Committee (including members of the public) designed a series of studies to allow decisions to be made about risks that might accompany exposure to the aerial spray.

This study, the first to be published, appears to throw fresh light on many factors of aerial Btk spray programmes, but even more it highlights the lack of research in many areas. The researchers conclude by noting that further detailed investigations and studies are warranted in the factors that influence drift, infiltration and indoor Btk concentrations and what determines fine aerosol production.

CONCLUSIONS & RECOMMENDATIONS

1. There is going to be spray drift outside the target zone, whatever the means of application, that will go much further, and last far longer than previously acknowledged or recognised. Further, the suspended aerosol sizes of active Btk spores are going to be of a finer more respirable size, and some will remain active for days rather than hours.

   Recommendation: That advice for prudent avoidance be given to residents at least one kilometre from the target spray zone. People at risk should be advised of the length of viable spore activity.

   Recommendation: MAF need to address the question of spray delivery - to maximise the droplet size and minimise aerosol break-up. Spraying days should take account of wind direction to reduce or eliminate drift into populated areas.

2. The drift and persistence of viable Btk spores in the environment will affect those households where rain provides their drinking water.

   Recommendation: Advice to be given to residents on rain or tank water - eg to divert collections for at least two rainfalls to clear any residues from the collection areas.

3. There is going to be high penetration of active Btk spores into buildings. Closing doors and windows, sealing chimneys etc will not effect the degree of infiltration. The persistence of viable Btk spores indoors beyond six hours has never been studied, but evidence from outdoor survival rates indicates it will be a severe problem. Recommendations for prudent avoidance are going to need urgent re-examination

   Recommendation: Unless spraying is done at weekends, all schools, playcentres, and any area where children will be present within the driftable zone, must be closed or evacuated the day of spraying. Elderly care homes and facilities should consider similar options.

   Recommendations: All residents within the drift zone must be advised of the timing of maximum penetration and probable persistence within their homes.

   Recommendation: Urgent investigation for minimising infiltration and/or mechanisms for 'venting' or cleaning houses should be undertaken now, and residents/schools etc advised accordingly. See 4 below.

4. The severe lack of data and quality studies in all areas of drift, aerosol sizes, building penetration, persistence etc, from both plane and helicopter delivery warrants immediate funded attention.

   Recommendation: That urgent review of the Canadian study and data is undertaken, and contact made with the prime researchers of the study to obtain further information for urgent investigations needed before spraying. (see

below) In addition, to determine with the researchers the areas where further research and investigation is needed.

Recommendation: That an experimental study is set up immediately to investigate mechanisms for 'venting' buildings of spray aerosols, both during spraying and afterwards, and determining ways of cleaning up or killing settled surface spores.

Recommendation: That given the short timescale before aerial spraying could commence, that funding availability be investigated as a matter of urgency for all possible research studies that should be undertaken.

[1] Gibbs N, Environmental Impact Assessment of Aerial Spraying Btk. Ministry of Forestry, July 1996

[2] Kay Teschke, Yat Chow, Karen Bartlett, Andrew Ross, Chris van Netten, Spatial and Temporal Distribution of Airborne *Bacillus thuringiensis* Var. *kurstaki* during an Aerial Spray Program for Gypsy Moth Eradication. University of British Columbia, Canada. Environmental Health Perspectives, Vol 109 (number 1) January 2001-10-31

[3] Thorogood R., Broadwell A., Chilcott C., Wigley P., Aerial Spraying of *Bacillus thuringiensis* Var. *kurstaki* in Auckland. i. Btk Spore Penetration into dwellings, ii Persistence of Air-borne Btk Spores. Report to the Ministry of Forestry, December 1996

APPENDIX 1

Abstract

Spatial and Temporal Distribution of Airborne Bacillus thuringiensis var. kurstaki during an Aerial Spray Program for Gypsy Moth Eradication

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Abstract
We measured airborne exposures to the biological insecticide Bacillus thuringiensis var. kurstaki (Btk) during an aerial spray program to eradicate gypsy moths on the west coast of Canada. We aimed to determine whether staying indoors during spraying reduced exposures, to determine the rate of temporal decay of airborne concentrations, and to determine whether drift occurred outside the spray zone. During spraying, the average culturable airborne Btk concentration measured outdoors within the spray zone was 739 colony-forming units (CFU)/m3 of air. Outdoor air concentrations decreased over time, quickly in an initial phase with a half time of 3.3 hr, and then more slowly over the following 9 days, with an overall half-time of about 2.4 days. Inside residences during spraying, average concentrations were initially 2-5 times lower than outdoors, but at 5-6 hr after spraying began, indoor concentrations exceeded those outdoors, with an average of 244 CFU/m3 vs. 77 CFU/m3 outdoors, suggesting that the initial benefits of remaining indoors during spraying may not persist as outside air moves indoors with normal daily activities. There was drift of culturable Btk throughout a 125- to 1,000-meter band outside the spray zone where measurements were made, a consequence of the fine aerosol sizes that remained airborne (count median diameters of 4.3 to 7.2 µm). Btk concentrations outside the spray zone were related to wind speed and direction, but not to distance from the spray zone.

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Environ Health Perspect 109:47-54 (2001). [Online 12 December 2000]
http://ehpnet1.niehs.nih.gov/docs/2001/109p47-54teschke/abstract.html