RESPONSE TO A GYPSY MOTH INCURSION WITHIN NEW ZEALAND

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A Paper presented at the IUFRO conference, Hanmer, 2004, and since updated July 2005

ABSTRACT

In March 2003, 10 years after implementation of a national trapping programme, the first ever gypsy moth was trapped in the North Island city of Hamilton. A national gypsy moth (*Lymantria dispar*) trapping programme was first implemented in New Zealand during 1993 in response to shipping from the Russian Far East, imported containers and the importation of used motor vehicles from Japan. Gypsy moth has the potential to cause severe damage to New Zealand's urban trees, indigenous forests and commercial forests. On confirmation that the insect was gypsy moth the Ministry of Agriculture and Forestry (MAF) as lead agency initiated response actions. Initial actions involved ground searching to a radius of 750 metres around the find and placing pheromone (disparlure) traps in a grid pattern out to a radius of 7 kilometres. Movement controls were placed on vegetation from a defined area.

Trace back on the likely source of entry into New Zealand was completed. The conclusion being that it was highly probable that the gypsy moth originated from Japan and arrived as an egg mass in association with an imported used car from Japan. A Technical Advisory Group (TAG) was convened and this group recommended that MAF proceed with eradication of the gypsy moth based around aerial spraying with Btk (formulation Foray 48B) at the rate of 5 to 7 litres/hecatre, followed by high-density trapping. The TAG agreed that other male and females from the same egg mass could have mated and the females laid new egg masses. Aerial spraying using Foray 48B was recommended as it provides the best method to cover a wide area in a short time, has been used previously over urban environments, and is a proven eradication technique against the gypsy moth. During the predicted early instar stage of the gypsy moth in New Zealand (October/November) eight aerial applications of Foray 48B were applied at weekly intervals over an area of 1253 hectares in West Hamilton. On conclusion of spraying additional disparlure traps were placed and two further ground searches completed. As at May 2005 no additional evidence of gypsy moth had been detected. Since no further activity was detected for two generations, and on the advice of the TAG, MAF declared eradication of the gypsy moth from Hamilton on 26 May 2005.

Keywords: Gypsy moth, aerial spraying, Foray 48B, disparlure, eradicate.

Gypsy Moth Surveillance

The gypsy moth is regarded internationally as a high impact pest causing major environmental and economic damage throughout many parts of the world. It defoliates trees and New Zealand perceives it as a very serious threat to our forest and horticultural industries, indigenous flora, ornamental trees and urban parks. A recently completed Economic Impact Assessment estimated that once established damage could amount to $88 million per annum at the high end.

To assist with detection in New Zealand a pheromone trapping system is implemented on an annual basis between November and April each year. The programme was first established in 1993 in response to ships and cargo entering New Zealand from the Russian Far East. More recently the exponential increase in imported Japanese used cars and high number of gypsy moth intercepts means trapping is highly necessary.

Traps are placed throughout New Zealand and are focused around ports, and specified high risk sites such as devanning sites, container yards and imported car storage yards.

Gypsy Moth Trapped in Hamilton

In March 2003 for the first time in New Zealand a live male gypsy moth was caught in one of the early warning traps placed in the North Island city of Hamilton, an entry point for transhipped cargo and cars from Auckland and other ports.

Immediately after the moth was found MAF implemented response actions. Initial activities involved ground searching around the site where the moth was trapped, deployment of traps baited with a chemical sex attractant and invoking of a Controlled Area. These actions were aimed at delimiting the population and controlling the gypsy moth's potential spread.

Validation through DNA profiling confirmed that the origin of the moth was Japan and it was of the Asian biotype, *Lymantria dispar* ssp. *praeterea.*

On completion of initial actions MAF assessed the situation and explored three options – do nothing, continue to monitor or implement eradication. MAF sought advice from top New Zealand and international scientists, overseas biosecurity agencies with experience of gypsy moth incursions, and relevant literature.

Is there a population established?

MAF's experts met several times to assess available information and the overwhelming conclusion was that one gypsy moth presented a significant risk of a population establishing and decisive action was needed to prevent the pest dispersing over a wider area.

The experts consulted agreed that evidence pointed to the trapped moth entering New Zealand via an egg mass that hitched a ride on a imported car or container from Japan. It was more than likely that the egg mass was laid in Japan between late May to early September and hatched here in January. It was believed that other moths hatched, mated, and laid eggs and that a population could well establish and expand from the egg mass.

So how was this conclusion reached?

Reasoning:

In the vicinity of the moth trapped in Hamilton there are a number of imported car yards and industrial sites processing goods and receiving sea freight containers imported from Japan. These imported risk items have a history of gypsy moth border interceptions.
Data on used vehicle imports from Japan for the years 2000 to 2002 record 428 interceptions of Lymantriid life stages. From August 2000 to June 2002 a sample of 152 Lymantriid interceptions were identified using DNA techniques at Lincoln University. Of these 116 were egg masses and 16 larvae.

A total of 137 samples were identified to species level and 124 of these were gypsy moth (107 egg masses, 9 larvae, 7 pupae and one adult). This data shows that we are more than 15 times more likely to intercept egg masses than pupae and 11 times more likely to intercept eggs masses than larvae.

MAF Quarantine Service has intercepted 66 viable egg masses and 57 egg masses for which viability was not determined during 2002 and 2003. In contrast, they have not intercepted a single pupae or larvae during that same period.

The life span of gypsy moth adults (moth) is 10 to 14 days and adults are present in summer through early autumn (May to September in Japan).

The developmental period of gypsy moth pupa is up to 2 weeks, and in the wild pupae are present in late spring and summer. The developmental period of gypsy moth larvae is 8 to 10 weeks and larvae are present in spring and early summer.

The developmental period of gypsy moth egg stage is about 9 months, including diapause and incubation period. Eggs are laid in summer and autumn and hatch in spring. Flight data of gypsy moth from Japan indicate that egg masses would be laid from mid May (southernmost part of Japan) to late August and early September (northernmost part of Japan). An egg mass most commonly contains 500 to 1000 eggs.

If the moth caught in Hamilton entered New Zealand as an adult moth it would have had to travel from Japan and reach the trap within two weeks. In March, when the moth would have had to leave Japan it is late winter and early spring and there are no adult moths present. The moth caught in Hamilton was still alive and in very good condition indicating a very short flight before being caught in the trap. It is therefore highly unlikely that the catch represented the entry of an adult male moth from Japan.

The flight data from Japan indicates that pupae (lasting 10 – 14 days) could have been present in Japan in mid April at earliest (in southernmost part of the range), well after the NZ trap catch on 26 March in Hamilton. It is therefore highly unlikely that the trap catch in Hamilton was a result of a pupa arriving from Japan.

If we assume the moth caught entered as a larva (caterpillar) it would have had to come from Japan in December to March. There are no larval stages present in Japan from December to February. However, there is a possibility that some early instar larvae could be present in Japan in March. If we assume this stage as the possible entry to New Zealand, it would be unlikely for larvae to develop to adult stage by March under the weather conditions present in Hamilton or elsewhere in New Zealand. It is therefore highly unlikely that the catch resulted from the entry of gypsy moth larvae from Japan.

Arrival as an Egg Mass

The conclusion reached was that is most likely that an egg mass arrived in Hamilton from Japan around December 2002 to January 2003 resulting in a male moth being caught in late March 2003.

Gypsy moth egg masses are a resilient, easily transported life stage often affixed to containers, vehicles and ships. Since the egg stage lasts almost nine months it provides an ideal pathway for long distance dispersal. The egg masses are often deposited by the female on inanimate objects and under structures or in crevices making them very difficult to detect during inspection. Gypsy moth females of Asian strain are attracted to lights, which increases a chance of eggs being laid on the imported cars, containers, ships and other inanimate objects awaiting loading in port in Japan.

The arrival of such an egg mass would have all preconditions for development satisfied as it would have been exposed to a period of low temperatures (vernalisation) in Japan before being shipped to New Zealand and exposed to higher temperatures that triggered egg development.

New Zealand Population?

Another scenario put forward was that there is a remote possibility that the moth originated from within New Zealand and arrived in Hamilton as an egg mass, larvae or pupa from somewhere else in New Zealand.

There is a possibility that this is the case. However, reassurance can be found in the fact that MAF operates a national trapping programme for gypsy moth (the original Hamilton trap is a part of that grid) and Hamilton was the only location where a moth has been captured. Also, MAF operates a number of other surveillance programmes and relies on the public to report suspect exotic organisms like gypsy moth. No gypsy moths have been reported elsewhere. It is therefore unlikely that there is a well established population of gypsy moth outside of the Hamilton infestation.

Under Hamilton climatic conditions and in the absence of natural predators and parasitoids quite a number of larvae could have developed to adulthood in an area close to the original egg mass. It is likely that there were other surviving male and female moths from the same egg mass. It is likely that they could have mated and the females laid new egg-masses. Based on the literature, in low density populations more females will be developing from one egg mass so one male caught in the trap may be representing a building population.

Even based on one male moth trapped there is a significant likelihood of a population of gypsy moth surviving into the second year (European strain, USDA data) without treatment.

The absence of another moth catch does not mean the trapped moth was alone
The male moth in Hamilton was caught very late in the season (compared to the similar latitude overseas) indicating the very end of the flight season. Additional traps to form a dense trapping grid were deployed a week after the trap catch. On assessment it is possible that traps were deployed after the end of flight activity.

Data from the literature indicate trap efficacy of 1-4% at trap densities applied in the Hamilton early warning gypsy moth grid (800 metres and more apart) at the time of the capture. There were a total of 17 traps in Hamilton. With this low trap density we could at best only expect to catch only four out of every hundred moths present in the area.

At low population levels gypsy moth is very difficult to detect due to the relatively low trap efficacy at the densities applied in Hamilton. The purpose of the national trapping grid is detection of a gypsy moth population early enough to be able to attempt eradication, rather than to trap high numbers of moth. Much higher densities of traps are needed to achieve higher levels of trapping grid efficacy.

The advisory group of experts MAF consulted agreed that one male gypsy moth in Hamilton presented a significant risk of a population establishing and sufficient reason to require prompt and decisive action to prevent further spread and establishment of the gypsy moth over a wider area.

What to do?
There are a number of options available to control or manage gypsy moth such as mass trapping, ground spraying, host removals and biological control, but for eradication purposes it was agreed that the only effective readily available tool available in New Zealand was aerial treatment with a bio-pesticide. Given the serious nature of the incursion, MAF accepted a recommendation that to achieve eradication an area of Hamilton would need to be aerial sprayed using Btk (Foray 48B) during the caterpillar stage of the next generation, i.e. spring/early summer 2003.

Following spraying it was agreed that a high density trapping grid would be placed in a 1km radius around the find. Pheromone trapping was seen as a method of detecting any remnant male moths before they mated with a female, thus assisting with eradication.

Aerial Spraying with Foray 48B

After much discussion, consultation and sign off by Government MAF was given the go ahead to aerial spray an area of Hamilton with Foray 48B to eradicate any potential population of gypsy moth. However, before spraying could commence MAF had to sign off on three critical decisions:

1. The size of the spray area
2. Number of sprays and application rate
3. Timing of spray application

Decision 1: Aerial Spray Area

One of the big decisions to make was what sort of area to spray? As it was not economically or technically justified to blanket spray all of Hamilton and surrounding towns, a well thought through spray area needed to be developed. Any area selected to spray needed to be defensible and provide the best assurance that the risk of a gypsy moth population establishing in New Zealand was reduced.

The captured moth was in good condition when found, indicating that it had flown only a short distance, probably originating from host trees in close proximity to the trap. Dispersal in the first year is usually within several hundred meters from the egg mass (most ballooning larvae do not disperse further than 800m although much longer distances have been recorded). There are quite a number of favourable hosts in the vicinity of the trap that caught the moth. The actual spray area agreed to was based around the following decision criteria:

Treat the trapped moth and associated row of oak trees as the epicentre

- No further activity had been found so there is no other data to work from.

Extend margins to a minimum of 1.6km from the epicentre, except where there is farmland

- The captured moth was in good condition when found indicating it had flown only a short distance.
- It is known that gypsy moth males seldom fly further than 800 metres.
- Taken that moths could have flown 800 metres in any direction then a minimum boundary of 1.6km will encircle a possible population.

- Include a 200-metre spray buffer for drift and deposition.

Keep the western boundaries away from farmland

- West and south of the trapped moth are areas of peat farmland.
- Vegetation is sparse and there is no value seen in spraying grassland.

Location of main host vegetation in Hamilton

- The majority of host vegetation (oaks, willows, poplars) are located to the east and north.
- Extend the boundaries where there are large areas of host vegetation.

Need to spray larger area as trapping programme was limited

- In the United States, for example, surveillance trap grids are much more robust.
- 17 traps were placed in Hamilton over 2002/03. The moth could have flown past the other traps.
- If it was certain that the moth emerged from the trap area then could justify smaller area.
- Need to be cautious and target larger area.

Include industrial area and devanning sites

- It is more than likely that gypsy moth arrived at an industrial site.
- The spray area includes all main devanning sites, used car yards and the industrial area.

Extend boundaries out to North and East

- Wind can disperse larvae and moths.
- Main wind direction would have led to north and east dispersal.
- Traps were not placed out this direction but targeted industrial sites.

The actual area agreed on was a 1250 hectare zone located around the moth find in West Hamilton.

Decision 2: Number of Sprays and Application Rates

The Technical Advisory Group (TAG) and manufacturer Valent BioSciences recommended that Foray 48B in Hamilton should be applied at between 5 and 7 litres/hectares and 6 to 8 sprays should be the goal. The recommended rate was believed to give confidence that high

mortality of the targeted pest gypsy moth (*Lymantria dispar*), was achieved and that eradication will have a high chance of success.

At the recommended rates Foray 48B has been shown to be particularly effective against the larvae of the Asian gypsy moth under operational conditions in both North America and Europe.

Aerial Applications 1 and 2

During aerial applications one and two Foray 48B was applied at 5 litres/hectare.
At this stage host trees were in bud burst and had not yet reached full leaf flush, and larvae were predicted to be in the earlier more susceptible stage. It was agreed that in this situation high larval mortality will be achieved.

Aerial Applications 3 to 8

During aerial applications three to eight Foray 48B was applied at 7 litres/hectare. A higher application rate was recommended to ensure mortality on advanced larval stages. Also targeted host species had reached full leaf expansion and a higher rate was necessary to permeate tree canopy and achieve sufficient deposition of Foray 48B on the foliage.

MAF recommended rates at the higher end of scale as the outcome required was eradication rather than control (i.e. foliar protection, population suppression) as is the situation in most overseas countries and against the European strain of gypsy moth in North America.

Decision 3: Spray Timing

The determination of spray timing was tricky due to no records of gypsy moth in New Zealand previously for modelling. As a recommendation two types of climate/day length modelling were completed to estimate when each gypsy moth life stage would be present in New Zealand.

Other variables assessed by MAF included leaf emergence of main host trees in Hamilton, criteria used in successful overseas eradication programmes for Asian gypsy moth, and current weather patterns in Hamilton.

Outcome

MAF started aerial spraying on 8 October 2003 and spraying was completed after eight treatments on 29 November 2003. Only two sprays were delayed by the weather.

Post Aerial Treatment

On completion of aerial spraying an additional 1700 pheromone traps were placed at 50 metre spacing around the area where the moth was trapped. Two further ground searches were carried out and movement controls monitored. No further activity was detected.

On 10 May 2005 the Technical Advisory Group met to consider eradication. The unanimous conclusion was that based on no sign of activity for two generations since aerial treatment was carried out, Asian gypsy moth could be declared successfully eradicated from Hamilton. MAF agreed with the recommendation, and an official declaration that eradication had been achieved was made by the Minister for Biosecurity on 26 May 2005.

Now the response has been completed, Hamilton will again be included within the national gypsy moth surveillance programme, with traps being placed on an annual basis around predetermined high risk sites between November and April.

On a final note some observers believe that the action taken by MAF to the capture of one gypsy moth in New Zealand was extreme. However, all measures taken have been backed by sound scientific and technical reasoning, and given the risk posed by the gypsy moth to the New Zealand environment MAF took decisive action and a successful conclusion to the programme will be well received by all involved in the response to a gypsy moth incursion in New Zealand.

Acknowledgments

BNZ wishes to thank the many people and organisations who assisted in the successful eradication programme. Special mention is to be made of the operational team involving AgriQuality, Forest Health Dynamics and Forest Research. The cooperation of the Hamilton community and scientific advice provided by the Technical Advisory Group was critical to the successful eradication of the Asian gypsy moth.