FINAL REPORT

To:
Horticultural Development Council
Bradbourne House
Stable Block
East Malling
Kent, ME19 6DZ

Novel insecticide treatments to control large narcissus fly

BOF 53

Rosemary Collier, Andrew Jukes,
Marian Elliott

January 2005

Commercial - In Confidence

Project title:	Novel insecticide treatments to control large narcissus fly
Project number:	BOF 53
Project Leader:	Rosemary Collier and Andrew Jukes Warwick HRI**,** Wellesbourne, Warwick CV35 9EF
Final report:	January 2005
Key workers:	Andrew Jukes (Insecticides) Marian Elliott (Insect rearing/experiments)
Location of project:	Warwick HRI, Wellesbourne, Warwick CV35 9EF
Project co-ordinator:	Adrian Jansen Lingarden Stonegate Weston Spalding, Lincs PE12 6HP
Date project commenced:	1 February 2004
Date project completed:	31 January 2005
Key words:	Large narcissus fly, *Merodon equestris,* narcissus, Actara (thiamethoxam), Calypso (thiacloprid), Decis (deltamethrin), Dursban 4 (chlorpyrifos), Hallmark with Zeon Technology (lambda-cyhalothrin), Tracer (spinosad), insecticide baits, foliar spray.

CONTENTS

Grower Summary

BOF 53

Novel insecticide treatments to control large narcissus fly

Final report 2005

BOF 53

Novel insecticide treatments to control large narcissus fly

Headline

- Experiments were done to determine which, if any, of the currently approved insecticides, or insecticides likely to achieve approval within the next 2-3 years, are effective against either large narcissus fly adults or larvae.

- In the laboratory, adult narcissus flies exposed to narcissus foliage treated with Hallmark with Zeon Technology (lambda-cyhalothrin) were affected most severely, Decis (deltamethrin) was less effective, and the two other insecticides tested (Tracer (spinosad), Calypso (thiacloprid)) were ineffective.

- When a small amount of sugar (10%) was added to the spray solution to act as bait, all the insecticides were more effective, but Hallmark was still the most active compound.

- Although the results of the laboratory experiments appear promising, we still do not know whether Hallmark will be effective in the field. There is an opportunity for growers to participate in a field trial in spring/summer 2005 (BOF 55) to determine whether foliar sprays of Hallmark will reduce narcissus fly infestations.

Background and expected deliverables

The large narcissus fly (*Merodon equestris*) is the most important pest insect of narcissus crops in the UK. Large narcissus flies overwinter as fully fed larvae within narcissus bulbs. In March or April, the larvae leave the bulbs and burrow through the soil to find suitable pupation sites near the soil surface. The adult flies emerge during May and June. After a period during which they feed and mate, the flies lay their eggs in the soil, close to the base of narcissus leaves, at a time when the leaves on many crops have already senesced. The eggs hatch after several days and the newly emerged larvae crawl down the outside of the plant and enter the bulbs through the basal plate. The larvae feed and grow inside the bulbs. Although more than one larva may enter a bulb, only one survives. The larvae are usually fully-grown by early winter. Infested bulbs fail to produce flowers and the most severely affected bulbs rot and die.

In the UK, narcissus crops remain in the soil for two or sometimes more seasons, which means that they are exposed to potentially two or more periods of infestation by the narcissus fly. Of the insecticide treatments available currently, a pre-planting chlorpyrifos dip (Spannit) is the most effective and provides high levels of control during the first growing season. At present, there is no effective insecticide treatment for control of narcissus fly during the second and third growing seasons, although early-lifting can help to reduce attack.

The UK narcissus crop covers over 3000 hectares, approximately 35% of which is grown in south-west England. Traditionally, Cornwall and the Isles of Scilly have been thought of as those areas most affected by the pest, due to a warmer climate and closer rotations. However, increasingly warm summers have seen populations on the increase in eastern counties, and the pest is now a significant problem on a number of farms. The summer of 2004 appears to have been particularly favourable for narcissus fly survival and there are reports that infestation levels are higher in Lincolnshire and Cornwall than they have been for some time. Extreme levels of infestation were as high as 30% and there were large numbers of stocks where 5-10% bulbs are infested. This has severe implications for the quality and value of the UK bulb crop.

The purpose of this project is to do laboratory and field cage experiments to determine which, if any, of the currently approved insecticides, or insecticides likely to achieve approval within the next 2-3 years, are effective against either large narcissus fly adults or larvae. The expected deliverables from this work include:

- An evaluation of the efficacy of insecticides applied as foliar sprays to foliage to kill large narcissus fly adults.
- An indication of the efficacy of foliar sprays of insecticide + sugar baits against large narcissus fly adults.
- An assessment of the efficacy of insecticide treatments applied to the soil to control newly-hatched large narcissus fly larvae.

If the results of these experiments appear promising, further work will be required to determine whether selected treatments are effective in the field.

Summary of the project and main conclusions

Three experiments were done to:

1. Determine whether insecticides applied to narcissus foliage at commercially viable rates kill adult large narcissus flies.
2. Determine whether fly mortality is increased by the addition of bait (sugar) to the insecticide spray solution.
3. Determine whether insecticide sprays to the soil surface are effective against narcissus fly larvae.

All the experiments were done in May-June 2004, using adult large narcissus flies that had emerged in field plots at Warwick HRI, Wellesbourne.

In the experiments using adults (see 1 & 2 above), the flies were kept in cages in the laboratory and exposed to narcissus foliage that had been sprayed previously with insecticide, or to unsprayed foliage (control treatment). In Experiment 1, the insecticides Calypso (thiacloprid), Decis (deltamethrin), Hallmark with Zeon Technology (lambda-cyhalothrin) and Tracer (spinosad) were applied at recommended rates, whilst in Experiment 2, the same treatments were applied, but a small amount of sugar (10%) was added to the spray solution to act as bait.

In Experiment 3, plastic flower pots were part-filled with loam compost and undamaged narcissus bulbs (cv Ice Follies) were placed in the pots. The pots were filled to the top with additional loam compost soil. Large narcissus fly eggs were inoculated onto each pot (4 eggs/bulb) and the eggs were covered with a thin layer of sieved field soil (to simulate their normal location). The pots were 'sprayed' with solutions of test insecticides (Actara (thiamethoxam), Calypso, Dursban 4 (chlorpyrifos), Tracer) at the appropriate rates. The pots were kept damp on capillary matting in a screenhouse (field cage) until January 2005. The bulbs were then removed from the pots and assessed to record damage and the presence of narcissus fly larvae.

Main conclusions

- Adult flies exposed to narcissus foliage treated with Hallmark were affected most severely and although many of them took several days to die, they became moribund in the intervening period. Decis was less effective than Hallmark. Calypso and Tracer were ineffective (Figure 1).
- When a small amount of sugar (10%) was added to the spray solution to act as bait, all the insecticides were more effective against adult flies, but Hallmark was still the most active compound (Figure 2).
- At the end of the pot experiment, very few of the bulbs were infested with live narcissus fly larvae and there was so little difference between the treatments that the data were not subjected to formal statistical analysis.

Figure 1. Percentage of large narcissus fly adults affected (either moribund or dead) following exposure to narcissus foliage sprayed with insecticide.

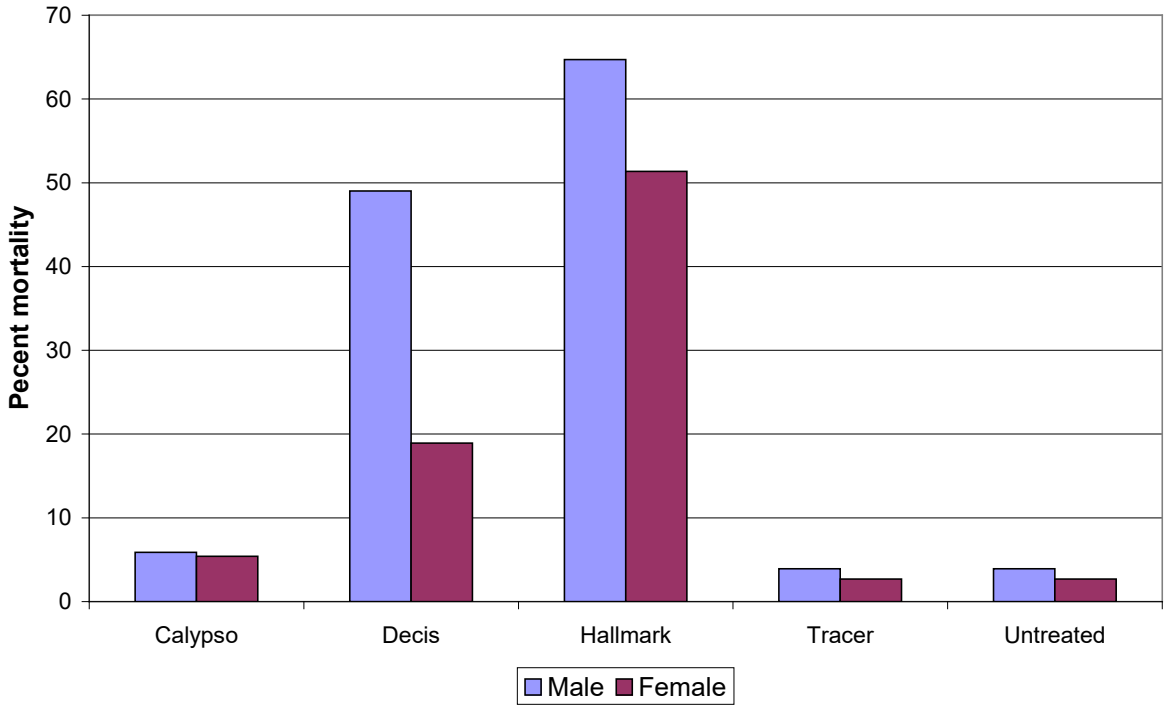
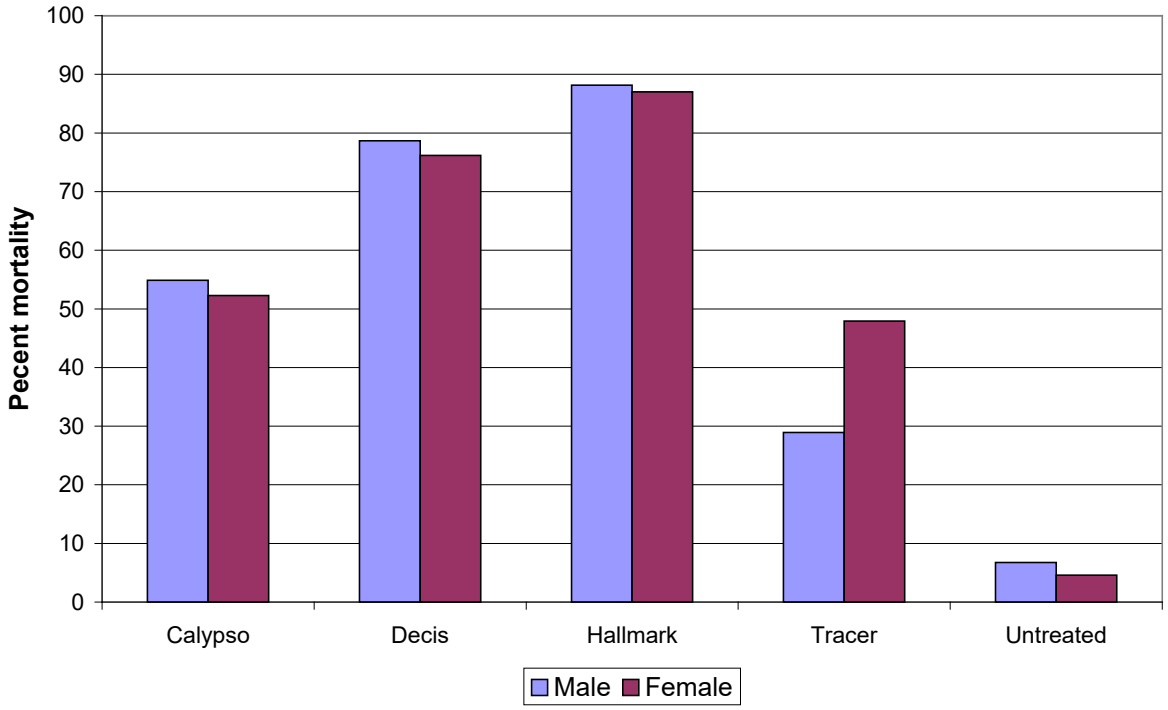


Figure 2. Percentage of large narcissus fly adults affected (either moribund or dead) following exposure to narcissus foliage sprayed with insecticide applied with bait (sugar).



Financial benefits

- Exports to both EU and non-EU countries are essential to the economy of the bulb industry, with £5m for bulbs and an additional £15m for narcissus flowers. Together with forced flowers, pot-grown bulbs and UK sales to retail outlets, the UK industry has an estimated farm gate value of £44m per annum.
- Narcissus fly infestation levels as low as 1% may jeopardise an entire consignment of bulbs, particularly if these are destined for export. Current control measures are nowhere near 100% effective, and the control strategy uses just one pesticide, chlorpyrifos.
- The proposed research is timely because:
    1) All uses of chlorpyrifos (including the bulb dip) are being questioned by PSD, due to concerns about adverse environmental effects of this insecticide.
    2) Narcissus fly infestations have increased during 2004.

Action points for growers

- Although the results of the laboratory tests on adult narcissus flies appear promising, we still do not know whether Hallmark will be effective in the field.

- A field trial will be done at Warwick HRI in spring/summer 2005 to determine whether foliar sprays of Hallmark reduce large narcissus fly infestations (BOF 55).

- There is also an opportunity for growers to participate in a field trial in spring/summer 2005 as part of the same project. Growers should contact Rosemary Collier at Warwick HRI, Wellesbourne (Tel: 024 7657 5066, e-mail rosemary.collier@warwick.ac.uk if they are interested in taking part.

SCIENCE SECTION

Introduction

As insecticides have not been evaluated against large narcissus fly (*Merodon equestris*) for some time, the overall aim of this project is to determine which, if any, of the currently approved insecticides, or insecticides likely to achieve approval within the next 2-3 years, are effective against either large narcissus fly adults or larvae. The three sub-objectives are to:

1. Determine whether insecticides applied to narcissus foliage at commercially viable rates kill adult large narcissus flies.
2. Determine whether fly mortality is increased by the addition of bait (sugar) to the insecticide spray solution.
3. Determine whether insecticide sprays to the soil surface are effective against narcissus fly larvae.

The products tested (with the active ingredient shown in parenthesis) were: Actara (thiamethoxam), Calypso (thiacloprid), Decis (deltamethrin), Dursban 4 (chlorpyrifos), Hallmark with Zeon Technology (lambda-cyhalothrin), Tracer (spinosad).

Materials and Methods

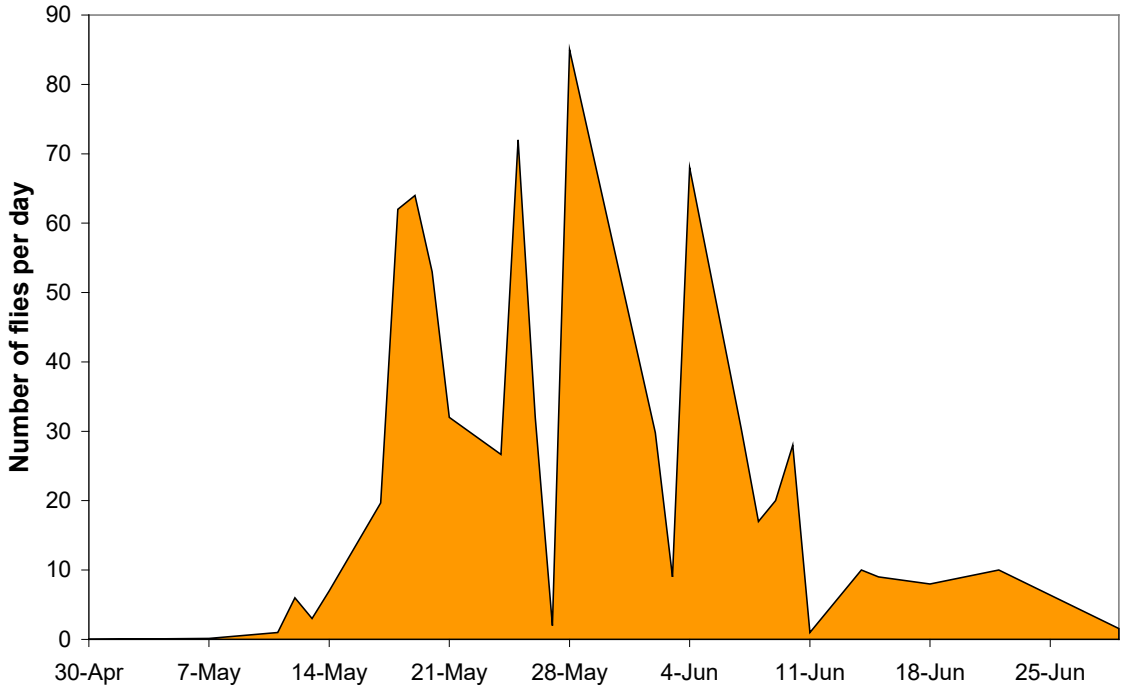
Production of large narcissus fly adults and eggs

Large narcissus flies were overwintered as fully-fed larvae inside bulbs in the narcissus plot (cv Ice Follies) at HRI Wellesbourne (winter 2003-4). Several thousand bulbs were dug up in February-March 2004 and screened for narcissus fly damage. The infested bulbs were re-buried in field plots that were covered subsequently with four large field cages (3 x 6 x 2 m high). Adult flies emerged into these cages during May-July 2004 (Figure 3).

The flies were captured on the day of emergence and held in the laboratory for use in insecticide trials, or they were allowed to lay eggs, which were used in insecticide trials against the larvae. Narcissus fly adults were held in 31 cm^3 Terylene net covered cages and were supplied with 10% sugar solution, yeast hydrolysate, powdered brewer's yeast and water (Finch *et al.*, 1990). The sugar solution was absorbed into cotton wool and presented in a 9 cm Petri dish, whilst the yeast hydrolysate was smeared onto another 9 cm Petri dish and covered with a fine layer of powdered brewer's yeast. Water was presented in a bottle with a wick made of blotting paper.

To collect eggs, flies were supplied with oviposition sites consisting of a Petri dish part filled with sieved field soil onto which some pieces of narcissus foliage were placed. Eggs were separated from the soil by emptying the contents of the Petri dish onto a fine mesh sieve and rinsing thoroughly with water. The eggs were removed using a fine paint brush and placed on damp filter paper held in 9 cm Petri dishes, where they were counted. Eggs were stored in a refrigerator prior to use.

Figure 3. Emergence of large narcissus fly adults into field cages at Wellesbourne in 2004.



Experiment 1.

Determine whether insecticides applied to narcissus foliage at commercially viable rates kill adult large narcissus flies.

Materials and methods

Insecticide solutions were prepared at a range of commercially viable rates. Four insecticides were tested (Calypso (neonicotinoid), Decis (pyrethroid), Hallmark (pyrethroid), Tracer (spinosyn)), representing a range of insecticide chemistries.

Narcissus foliage was collected from the field plot. For each of the treatments, a sample of foliage was spread out on a metal tray. Insecticide solutions were made up in water (Table 1). The foliage was then sprayed using a hand sprayer (6 "pumps" for each treatment) to give an approximate spray rate equivalent to 300 l water/ha. The procedure was done in the pesticide handling unit at Warwick HRI, Wellesbourne. The insecticide treatments were allowed to dry and then the samples of foliage were brought into the laboratory and placed into 'test' cages in a controlled environment room (18±2ºC; 16 h photoperiod). Samples of untreated foliage were used as control treatments.

Adult flies collected from the emergence cages in the field plot were released into the test cages (2 cages per treatment). The flies were supplied with a source of food and water. Fly behaviour and mortality were assessed over three days. The experiment was replicated on four occasions (17, 20, 24, 27 May) and a total of 88 flies (51 male, 37 female) were exposed to each treatment.

Analysis

The proportion of narcissus flies affected (dead or moribund) by each treatment was analysed using a Generalised Linear Model assuming a binomial distribution and a logit link function. The efficacy of each treatment was assessed by considering the treatment effect on the logit scale.

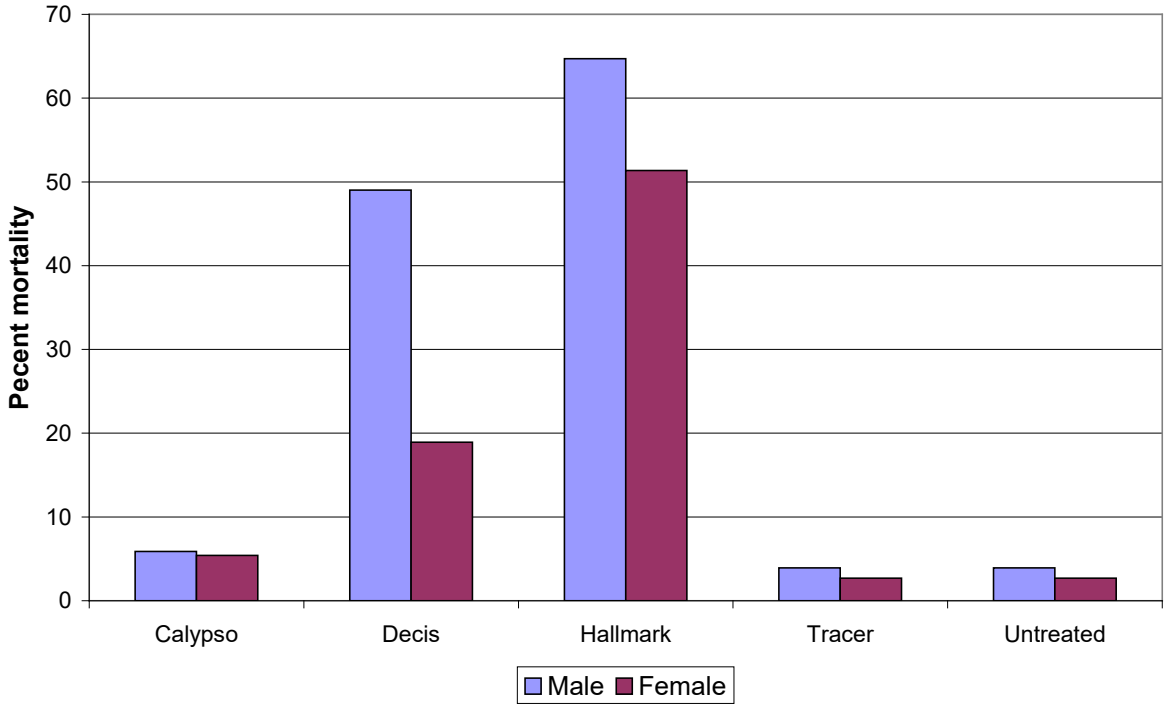
Table 1. The insecticides and rates of application to narcissus foliage used in the experiments to control adult narcissus flies (Experiments 1 & 2).

Product	**Active Ingredient**	**Concentration**	**Rate (ml product/ha)**	**Rate (g a.i./ha)**
Calypso	Thiacloprid	480 g/l	375	180
Decis	Deltamethrin	25 g/l	300	7.5
Hallmark with Zeon Technology	Lambda-cyhalothrin	100 g/l	150	15
Tracer	Spinosad	480 g/l	200	96

Results

Although many of the flies took several days to die, they became moribund in the intervening period. Exposure to foliage treated with either Hallmark or Decis gave a statistically significant increase in the proportion of male flies affected in comparison with the untreated control ($p<0.001$). Both these insecticides were less effective against female flies, particularly Decis ($p=0.052$). Neither Tracer nor Calypso produced a statistically significant treatment effect (Figure 4).

Figure 4. Percentage of large narcissus fly adults affected (either moribund or dead) following exposure to narcissus foliage sprayed with insecticide.



Experiment 2.

Determine whether fly mortality is increased by the addition of bait (sugar) to the insecticide spray solution.

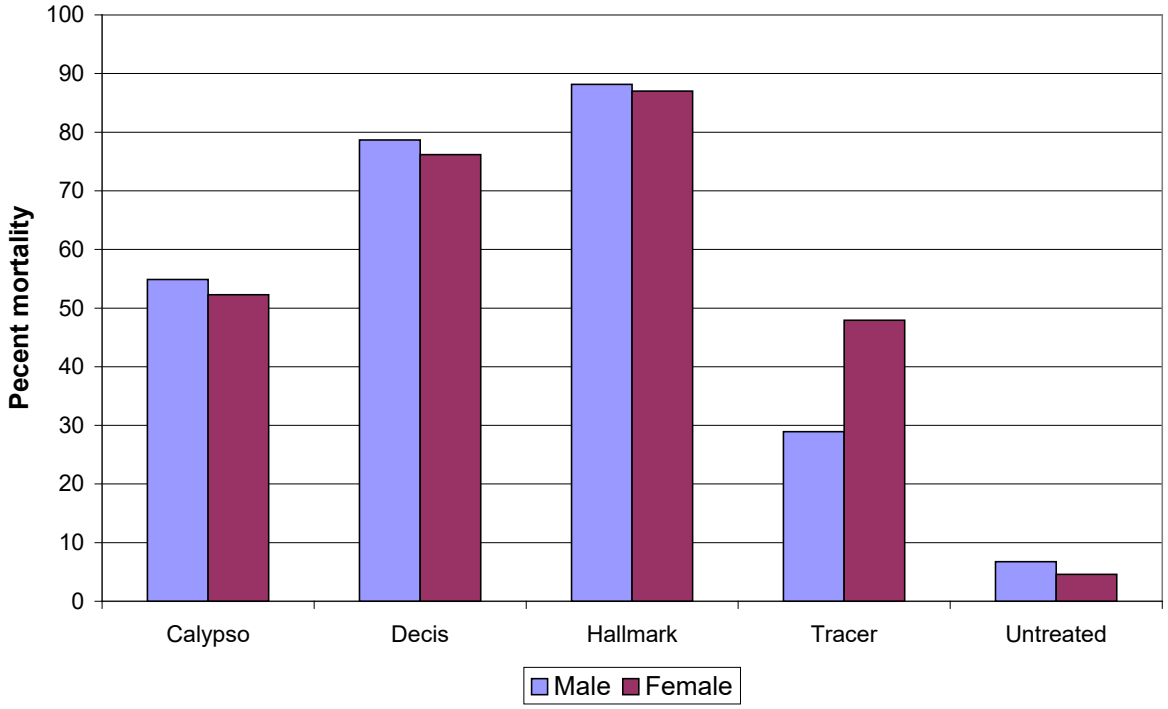
Materials and methods

The experimental procedure outlined for Experiment 1 was repeated, but this time the insecticides were applied in a bait solution (containing 10% sucrose). The experiment was replicated on three occasions (2, 7, 11 June) and 88 flies (43 male, 45 female) were exposed to each treatment. The data were analysed as for Experiment 1.

Results

The addition of sugar as a bait made all the insecticide treatments more effective and all of them were different from the untreated control ($p<0.02$). Hallmark was still the most active compound (Figure 5).

Figure 5. Percentage of large narcissus fly adults affected (either moribund or dead) following exposure to narcissus foliage sprayed with insecticide applied with bait (sugar).



Experiment 3.

Determine whether insecticide sprays to the soil surface are effective against narcissus fly larvae.

Materials and methods

One hundred plastic flower pots (15 cm diameter dumpy pots) were part-filled with loam compost. Undamaged narcissus bulbs (cv Ice Follies) were dug from the field plot at Wellesbourne and placed in the pots (10 bulbs/pot). The pots were filled to the top with additional loam compost soil. Adult flies collected from the field emergence cages were kept in a constant environment room at a temperature of 20-22ºC, supplied with food and water and allowed to lay eggs. The eggs were collected and held in a refrigerator for up to 7 days until there were sufficient to use in the experiment.

Forty eggs were inoculated onto each pot (4 eggs/bulb (Finch *et al*., 1990)) on 21-22 June and the eggs were covered with a thin layer of sieved field soil (to simulate their normal location). The pots were sprayed on 25 June 2004 at a rate of 1000 l water/ha using a calibrated knapsack sprayer with solutions of the test insecticides at the specified rates (Table 2). Twenty pots were treated with each insecticide and twenty pots were left untreated as a control. The pots were kept damp on capillary matting in a screenhouse (field cage) until January 2005. The bulbs were then removed from the pots and assessed to record damage and the presence of narcissus fly larvae.

Table 2 The insecticides and rates of application used to control narcissus fly larvae on bulbs.

Product	Active Ingredient	Concentration	Rate (ml product/ha)	Rate (g a.i./ha)
Actara	Thiamethoxam	250 g/kg	400	100
Calypso	Thiacloprid	480 g/l	375	180
Dursban 4	Chlorpyrifos	480 g/l	960	461
Tracer	Spinosad	480 g/l	200	96

Results

The total numbers of healthy, infested and rotten bulbs recovered from the 20 pots from each treatment are shown in Table 3. Very few of the bulbs were infested with live narcissus fly larvae and the difference between the treatments was so small that the data were not subjected to formal statistical analysis.

Table 3. Total numbers of infested, healthy and rotten bulbs recovered from 20 pots from each treatment.

Product	Number of bulbs		
	Infested	Healthy	Rotten
Actara	2	221	9
Calypso	2	209	7
Dursban 4	1	238	5
Tracer	4	223	7
Untreated	2	218	7

CONCLUSIONS

The large narcissus fly is normally a 'low density' pest and field experiments to demonstrate the efficacy of insecticides are often difficult to interpret because of the patchy distribution of the fly and the relatively low numbers of infested bulbs. It was decided therefore to screen the bulbs under controlled 'laboratory' and 'field cage' conditions using insects from the narcissus fly population established at Warwick HRI.

In the tests using adults, flies exposed to Hallmark were affected most severely and, although many of them took several days to die, they became moribund in the intervening period. Decis was also relatively effective. In the second test, when a small amount of sugar (10%) was added to the spray solution to act as bait, all the insecticides were more effective against adult flies, but Hallmark was still the most active compound.

The results from the third experiment where insecticides were applied to the soil to control large narcissus fly larvae were extremely disappointing, because the numbers of larvae that survived in all the treatments were too low to conduct a meaningful statistical analysis. The inoculation rate used in the experiment was similar to that used in a previous study (Finch *et*

al., 1990) when larvae developed successfully in 100% of bulbs. However, natural mortality of eggs and/or larvae must have been much higher on this occasion.

Because the results of the laboratory experiments to screen insecticides for control of adult large narcissus fly appeared promising, a further proposal was put to the BOF Panel for a new project, to evaluate the performance of Hallmark in the field. The overall objective of the new project (BOF 55) is to demonstrate whether Hallmark will kill adult large narcissus flies under field conditions. The proposed study will consist of a field plot experiment at Warwick HRI, supported by field-scale trials on commercial holdings.

TECHNOLOGY TRANSFER

Results from the project were presented at an NFU Bulbs meeting at the Duchy College, Camborne Cornwall on 25 November 2004.

Articles:

Collier, R.H. & Jukes, A.A. (2004). Flies on the move. HDC News October/November 2004, 16-17.

ACKNOWLEDGEMENTS

We thank the HDC for funding this work and the project co-ordinator, Adrian Jansen, for his help. We are also grateful to the manufacturers who supplied us with samples of their products. Statistical analyses were done by Andrew Mead, Warwick HRI.

REFERENCES

Finch, S., Collier, R.H. & Elliott, M.S. (1990). Biological studies associated with forecasting the timing of attacks by the large narcissus fly, *Merodon equestris.* Proceedings 1990 Brighton Crop Protection Conference - Pests and Diseases, 3A-4: 111-116.

