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Research Report

FV/44 Final Report

Horticultural Brassicas:
Forecasting and control of Pollen Beetle

HDC Project FV44

FINAL REPORT

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Horticultural brassicas: Forecasting and control of pollen beetle

INTRODUCTION

In recent years, feeding by adult bronzed blossom beetles (*Meligethes* spp.) on the florets of calabrese and cauliflower has reduced considerably the marketability of many crops. Apart from the direct damage done by the grazing beetles, the beetles often conceal themselves within calabrese heads so that when plastic-wrapped packs of produce are transferred from cool stores to shop temperatures, the beetles become active inside the packs.

Adult bronzed blossom beetles overwinter in the soil in sheltered well-drained sites alongside hedgerows and similar shelter barriers. The beetles become active during late-March to early-April in the UK, but do not fly to brassica crops until about a month later when mean daily temperatures rise above 15°C. On arrival at an oilseed rape or other flowering brassica crop, the beetles aggregate alongside shelter barriers. However, within days, the beetles move into the crop and start to feed on the buds and flowers. During feeding, females chew holes 2-3 mm in length, in the bases of the unopened flower buds and lay 1-3 eggs in each hole. The larvae which hatch feed initially on pollen but later move to unopened flowers and finally onto the newly-formed seed pods. After feeding for 25-30 days, the fully-grown larvae drop to the soil where they pupate in earthen cells. Young beetles emerge 2-3 weeks later and, although some of them feed for a short time on newly-formed seed pods within oilseed rape crops, the majority leave to feed on other plants.

At this time, the newly-emerged beetles feed to accumulate reserves that maintain them through the winter period. Although the beetles have a strong preference for cruciferous plants, such as calabrese and cauliflower plants, many beetles fail to locate such crops and instead feed on the pollen of weeds and garden flowers.

Trapping beetles for four years at Wellesbourne, and for one year at several sites throughout the UK, has provided data on the variations in the timings of beetle attacks both between years and between sites. Between years there was a difference of 25 days in the timing of 50% beetle activity. In general, beetle activity was later the further north the monitoring site.

For the immediate future it seems unlikely that the current high populations of bronzed blossom beetles will decline to a level that will not damage mid-summer crops of cauliflower and calabrese. As a consequence the aim of this research is to develop a practical system for forecasting the timing of appearance of these beetles so that control procedures can be made as accurate as possible.

EXPERIMENTAL

The experimental work was divided into the following 3 studies:-

1. DEVELOPMENTAL BIOLOGY - This involved studies of the developmental biology of *Meligethes* under field and laboratory conditions to determine the relationship between the rate of *Meligethes* development and temperature. Such relationships form the bases of forecasting models.

2. MONITORING BEETLE ACTIVITY IN THE FIELD - Insect traps were used to monitor the changes that occur in beetle populations from region-to-region and from one year to the next.

3. DEVELOPMENT OF THE FORECAST - Information obtained mainly in the first study was used to develop the forecast. The accuracy of this forecast was assessed using data from the second study concerning the numbers of beetles caught in traps in the field.

1. DEVELOPMENTAL BIOLOGY

MATERIALS AND METHODS

Adult bronzed blossom beetles ~~was~~ collected from flowering crops of Chinese cabbage, radish and calabrese during June-August 1990. The beetles were released into a large Tygan^R field cage that had been erected earlier over a banked hedgerow. The beetles were supplied with brassica flowers as food until they entered hibernation at about the end of August. During early spring 1991, samples of soil containing the hibernating beetles were removed from the base of the hedge using a 10 cm soil corer. The soil cores were used either immediately for experiments or stored in large plastic sacks in a cold store at 4°C until required.

As soon as the beetles became active in the field cage (March) their activity was monitored using a single yellow sticky trap, which was renewed each week.

Temperature requirements for beetles emergence in the spring

On 22 January 1991, nine soil cores were taken from alongside the caged part of the hedgerow. The cores were broken up, placed on a tray inside a beetle-proof cage, and maintained at 20°C inside a controlled environment room. Beetles began to emerge after 6 days and continued to emerge for about a month. More than 200 beetles emerged in total.

Further soil cores were taken from alongside the hedgerow on 5 February 1991. Individual soil cores were placed into ventilated clear-plastic boxes and were held in cooling incubators at either 10, 11.5, 14, 15, 16.5, 19, 21.5 or 24°C with an 18 h photoperiod.

Further samples were taken on 1 March 1991. These cores were maintained in the same range of cooling incubators and in an incubator maintained at 26.5°C.

Temperature requirements for egg-laying by the beetles

Newly-emerged beetles were kept in ventilated plastic boxes in cooling incubators maintained at temperatures between 10 and 21.5°C. The boxes were lined with paper towels that were moistened with water. All beetles were provided with greenhouse-grown racemes of white mustard, as both food and an oviposition site. The racemes provided a range of flowering stages from open flower to small bud. The beetles preferred to lay their eggs in the small buds. All racemes were renewed at regular intervals. Those removed from the test cages were dissected under a binocular microscope to search for eggs. The numbers of eggs laid were recorded.

Temperature requirements for egg hatch

Large numbers of field-collected *Meligethes* were maintained in ventilated glass-sides cages in a controlled environment room at 20°C (18 h photoperiod). These beetles were provided with racemes of white mustard, which were replaced daily. The buds were dissected carefully under a binocular microscope to search for eggs. Newly-laid eggs, placed onto pieces of damp filter paper in small plastic boxes, were maintained at temperatures between 10 and 21.5°C. The eggs were examined regularly to determine the day of hatching.

Temperature requirements for egg and larval development

Freshly-collected wild charlock or white mustard racemes were presented to caged adult *Meligethes*. The field-collected charlock was immersed in cold water to drown any wild *Meligethes* larvae. After one day, the submersed racemes were removed and placed in a jar of water. The jar was put into a polythene bag and, to prevent the larvae that fell off the plant from drowning, the polythene bag was tied around the plant stems with a piece of fine wire. Each jar was then stood in the centre of a white plastic dish and enclosed with a cylinder of white paper to protect the feeding larvae. The dishes were maintained in incubators at between 10 and 21.5°C. The plant material and dishes were examined at regular intervals to collect the mature beetles larvae that fell from the plants to pupate. These larvae were placed in small boxes containing damp peat in which they could pupate. Small larvae found in the dishes were put back onto flowers. Fresh white mustard racemes were added regularly.

Pupation and pupal development

The small boxes of compost that contained the mature larvae were maintained in the incubators and examined regularly. Some of the larvae formed pupation cells at the bottom of the boxes. From these it was possible to estimate the times required for pupation. The time for the insects to pupate and for the adults to emerge from the peat were recorded at a range of constant temperatures between 10 and 21.5°C.

RESULTS

Effects of temperature on *Meligethes* development

Figure 1 shows regression lines fitted to the relationships between the rate of *Meligethes* development (expressed as percentage of total development completed per day) and temperature for the major stages/phases in the life-cycle of the beetles. Table 1 shows the durations of each stage at 11.5 and 19°C and the low temperature threshold, estimated by extrapolation of the fitted regression lines in Figure 1.

When soil samples were taken on 5 February 1991, the time for 50% of the adults to emerge ranged from 29 days at 11.5°C to 12 days at 19°C. By 1 March, these figures had decreased considerably and ranged from 11 days at 11.5°C to only 5 days at 19°C.

Estimates of the low temperature thresholds for the various stages in the life-cycle of the beetle ranged from 1.8 to 7.5°C.

2. MONITORING BEETLE ACTIVITY IN THE FIELD

MATERIALS AND METHODS

The activity of adult *Meligethes* was monitored in 1989 using fluorescent yellow water traps, and in 1990 and 1991 using yellow sticky traps. All traps were maintained at crop height in crops of calabrese, cauliflower and oilseed rape. Depending on beetle numbers, traps were replaced every 1 to 7 days. Small numbers of beetles were counted directly, whereas large numbers of beetles were estimated from sub-samples. Traps were located at Wellesbourne, Warwickshire (1989-1991); Mepal, Cambridgeshire (1990-1991); Kirton, Lincolnshire (1990-1991) and Cawood, Yorkshire (1989-1991). Beetles were trapped throughout June, July and August.

RESULTS

In 1990, as many as 3,000 beetles/trap/day were captured during the peak summer migration at both Wellesbourne and Cawood. More than 18,000 beetles were captured per trap during this period (Table 2). At all sites, fewer beetles were trapped in 1991 than in 1990. However, at each site and in each year, the numbers of beetles trapped in brassicas were of the same order of magnitude as those trapped in oilseed rape crops. When the numbers of beetles captured per trapping interval (2-3 days) at Mepal in 1990 were plotted against the mean maximum air temperature during the trapping period, the numbers of beetles captured were related directly to temperature. At Wellesbourne in 1990 and 1991 the monitoring traps were replaced daily from Monday to Friday. Few beetles were captured when the maximum air temperature was below 19°C and the threshold for activity by beetles appeared to be close to 17°C.

3. MODELLING *Meligethes* DEVELOPMENT

MATERIALS AND METHODS

Information collected on the relationship between the rate of beetle development and temperature was used to generate a simulation model for forecasting the timing of the summer migration of beetles into susceptible horticultural brassica crops.

The model was based on ones that had been developed previously to forecast the timing of cabbage root fly and carrot fly activity. The current model simulated the development of *Meligethes* from early spring (1 February). It was based on equations derived from the data collected in the "Developmental Biology" part of this study. Both linear and non-linear equations were used to describe the relationship between the rate of beetle development and temperature.

Meligethes development was summarised using the minimum number of equations. These were the four equations for the phases in the life-cycle of the beetles covering the following periods:

1. Spring development of overwintering adults - to the time when beetles emerged from the soil
2. Egg maturation - to egg laying
3. Egg and larval development - to the time when fully-fed larvae dropped off their host plants
4. Pupation and pupal development - until the new generation of adults emerged from the soil

A threshold temperature for the summer migration was also included in the model by assuming that beetle would not fly on days when the maximum air temperature was below 17°C.

The model was run for the four sites at which at least two years' monitoring data were available. The output included 1) the timing of beetle emergence in the spring; 2) the timing of egg-laying, and 3) the timing of the summer migration of the beetles. All forecasts were derived from a population of 500 *Meligethes* individuals. The forecasts (expected) were then compared with the results (observed) from the monitoring data.

RESULTS

Comparison of real and forecast *Meligethes* activity

Spring emergence

Spring emergence was monitored in the field only in 1991, when adult *Meligethes* were captured on a single yellow sticky trap placed in the overwintering field cage. First beetles were caught on 13 March (maximum air temperature 18°C) and peak numbers were captured in the week ending 14 April (maximum air temperature above 16° on three days). First emergence (10%) was forecast for 15 March, 50% emergence for 25 March and 90% emergence for 3 May 1991. The period in which large numbers of pollen beetles were trapped coincided with the latter part of the forecasted period of pollen beetle emergence. It is likely that although the beetles had emerged prior to this date, air temperatures were too low for them to fly and be captured on the yellow trap (maximum temperatures in early March were between 7 and 14°C).

Egg laying and summer migration

Figure 2 shows the numbers of *Meligethes* trapped at Wellesbourne in 1989, compared with forecasts of egg-laying and the summer migration. Although pollen beetles were captured in the cauliflower crop throughout June, large numbers were trapped only at the beginning of the summer migration. Figure 3 shows comparisons between forecasted and observed activity for several other site/year combinations.

The times at which *Meligethes* were active under field conditions were compared with those forecasted, by comparing the times for 10% and 50% beetle activity during the summer migration. The forecasted activity was compared to beetle activity in both horticultural brassicas and oilseed rape crops. Differences between forecasted and observed beetle activity were less variable (± 3 days) in oilseed rape crops than in horticultural brassica crops (± 5 days). However, over all site/year combinations, the timing of activity in oilseed rape was no earlier than in the horticultural brassicas.

CONCLUSIONS

1. Overwintering beetles were caught on yellow sticky traps from when spring temperatures rose above 15°C until the end of the egg-laying. Large numbers of beetles were trapped also during the summer migration period.

2. Capturing beetles in oilseed rape crops did not provide an early warning of when beetles migrate during the summer. The number of beetles caught in horticultural brassica crops and oilseed rape crops were similar.

3. In the absence of a temperature-based forecasting system, an early warning of

the summer migration of *Meligethes* would be possible only if beetle pupae could be collected from the soil beneath oilseed rape crops and their subsequent development recorded under controlled laboratory conditions.

4. Forecasts of the summer activity of *Meligthes* were accurate to within one or two days. This migration could probably be predicted quite accurately one or two weeks in advance.

5. The differences between the observed and forecasted times of beetle activity were less variable in oilseed rape crops, probably because the beetles are trapped close to their sites of emergence. In contrast, the beetles trapped in horticultural brassica crops generally have to travel some distance before being trapped. Even so, the time taken for beetle migration must be relatively short, as beetles were not caught earlier in oilseed rape crops than in horticultural brassica crops.

6. It was apparent that even in areas of intensive oilseed rape production, an attack by *Meligethes* is not inevitable. During 1991, beetle numbers were lower at all sites than in 1990 and were extremely low at two sites. Therefore, the forecast should be used to warn growers of the likely arrival of *Meligethes*. The intensity of the attack can then be assessed by placing yellow traps in the crop or merely by examining the crop plants. The decision of whether or not to spray can be made from this information and thereby reduce pesticide usage to the absolute minimum.

SUMMARY

The rates of development of several stages/phases in the life-cycle of the bronzed-blossom beetle (*Meligethes* spp.) were measured in the laboratory at a range of constant temperatures. Linear regression lines were fitted to the data and low temperature thresholds were estimated by extrapolation. These thresholds ranged from 1.8°C to 7.5°C.

The four major "phases" of development:- 1) emergence of beetle in the spring; 2) egg maturation; 3) egg and larval development; and 4) pupation and pupal development, were described using linear or non-linear rate equations. These equations were linked in a computer program and, using soil and air temperatures from the field, were used to simulate *Meligethes* development in the field. The program was run using weather data from sites where appropriate *Meligethes* monitoring data were also available.

The forecast was used to predict the timing of the summer migration of beetles from oilseed rape fields to horticultural brassica crops. Forecasted and observed beetle activity were compared and differed by approximately 5 days when *Meligethes* were monitored in horticultural brassica crops and 3 days when *Meligethes* were monitored in oilseed rape crops. However, beetles were not caught earlier in oilseed rape crops than in horticultural brassica crops. Therefore, monitoring *Meligethes* in

oilseed rape crops does not provide an early warning for the summer migration of beetles. Large numbers of *Meligethes* were trapped at all sites in 1990, fewer in 1991. Attacks by large numbers of *Meligethes* are not inevitable. Hence yellow sticky traps should be used in conjunction with the forecast to determine whether the numbers of beetles in the crop merit the application of insecticide.

ACKNOWLEDGEMENTS

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Table 1. Effects of temperature on the various stages/phases of development of *Meligethes*

Stage/phases	Duration in days at:- 11.5°C	19°C	Low temperature threshold (°C)
Spring emergence	29	12	4.4
Egg maturation	62	22	7.4
Egg development	9	3	7.0
Egg to fully-fed larva	22	12	1.8
Pupation	19	8	7.5
Pupation and pupal development	64	23	6.5

Table 2. Total numbers of *Meligethes*, captured per trap during the summer migration in 1989, 1990 and 1991

	1989	1990		1991	
	Brassica	Brassica	Rape	Brassica	Rape
Wellesbourne	1,800	7,800	15,700	7,900	7,300
	310	19,600	14,200		
			19,100		
			23,200		
Mepal		3,500	1,800	120	16
Kirton		1,300	1,100	12	9
Cawood	310	18,500	9,100	1,400	1,200

Figure 1. The rate of *Meligethes* development at a range of constant temperatures between 10°C and 25°C.

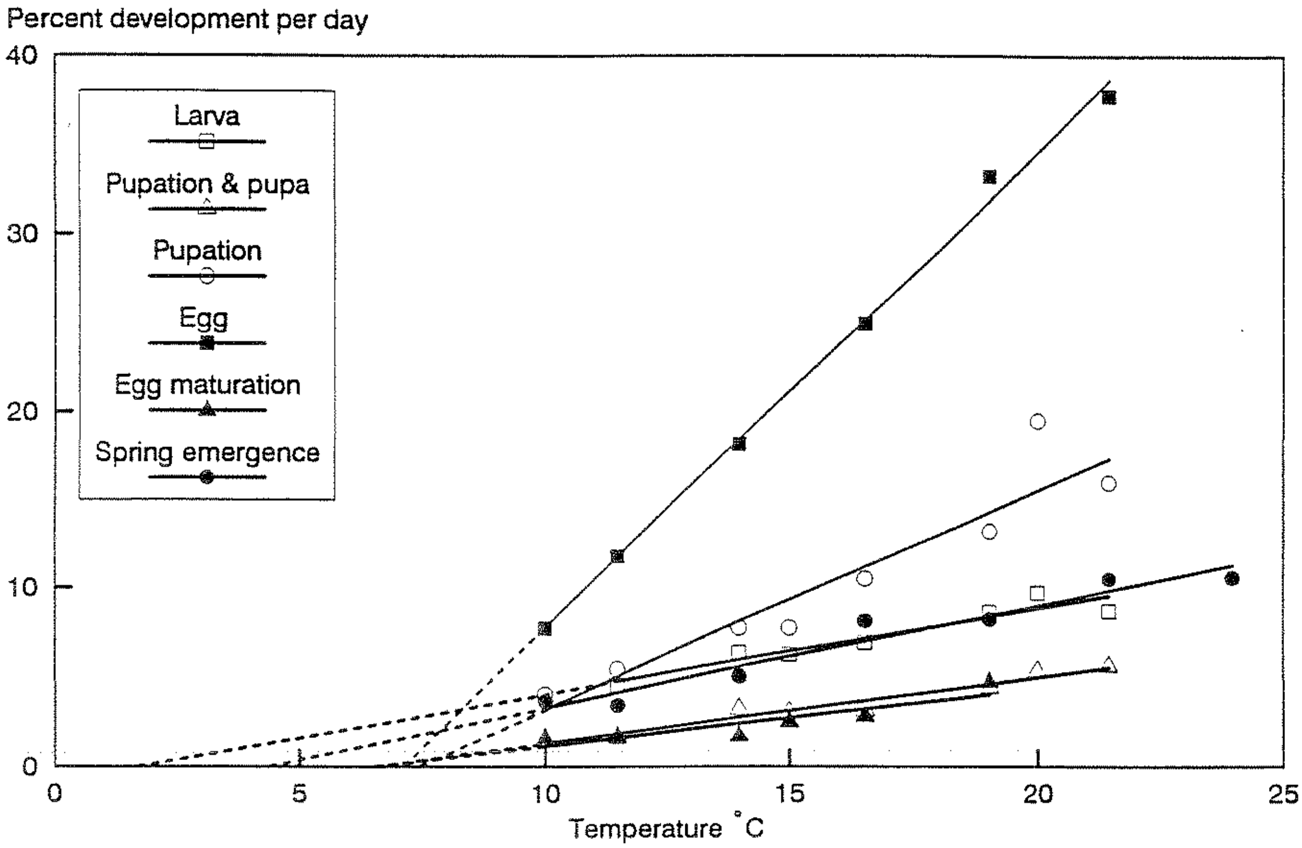

Figure 2. The numbers of *Meligethes* trapped in a cauliflower crop at Wellesbourne in 1989 compared with the forecasted time of activity of egg-laying by the overwintering beetles and summer migration of the following generation of beetles.

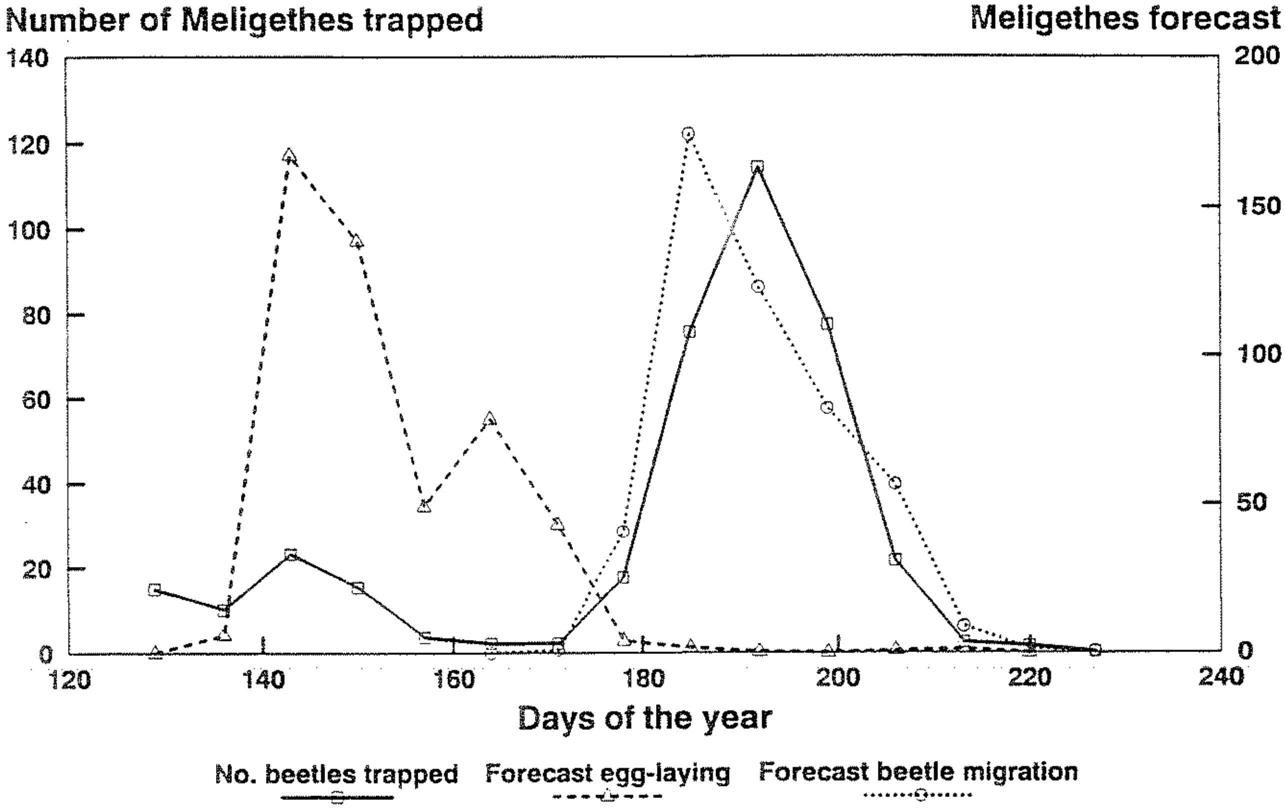

Figure 3. Comparisons of observed and forecasted activity of *Meligethes* at a range of sites during 1990-1991. [------] number of beetles trapped in brassica crops; [.......] number of beetles trapped in oilseed rape crops; [_____] forecasted beetle activity based on population of 500 insects.