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INTERIM PROJECT REPORT

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Control of capsid bugs within IPM programmes in protected crops.

Second Interim Report

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Commercial – In Confidence

INTERIM REPORT

Project title:	Control of capsid bugs within IPM programmes in protected crops.
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The results and conclusions in this report are based on a series of experiments and surveys. The conditions under which the work was carried out and the results have been reported with detail and accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results especially if they are used as the basis for commercial product recommendations.

Authentication

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

Signature ....

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PRACTICAL SECTION FOR GROWERS

Background

Capsid bugs belong to the Miridae; a large family of small to medium sized soft bodied insects which exploit a wide range of diverse habitats. The majority of species are plant feeders but a few are at least partly predatory (eg black-kneed capsid). In recent years, some plant feeding species have caused sporadic but important problems in protected salad crops, particularly cucumbers, peppers and aubergines.

In the first year of this project, detailed crop monitoring at two sites in Yorkshire provided a much improved understanding of capsid problems in cucumbers and peppers. Two species were found to be causing damage; *Lygus rugulipennis* in cucumber crops and *Liocoris tripustulatus* in pepper crops. Detailed examination of vegetation in the immediate vicinity of the infested greenhouses failed to locate important capsid breeding sites. It was therefore assumed that the insects migrate to the greenhouses from other areas.

A total of 120 cucumber, pepper and aubergine growers participated in a national survey in 1997 and 48 confirmed that they had seen capsid activity in their crops. Approximately one third of those who had seen damage, reported that it occurred over large areas of their crops. The most seriously affected were cucumbers where the estimated financial loss ranged from £300 to £2000 per 1000m^2. Many of the growers who reported less serious damage had restricted the development of the problem by applying broad spectrum insecticides but indicated that this had affected biological control of other pests and had resulted in secondary problems. The survey confirmed that this was a nationwide problem which had become much more serious during the last four years.

Objectives

The overall objective of the project was to improve the knowledge of the biology and behaviour of plant feeding capsids in protected crops as a first step in formulating a sustainable control strategy within existing IPM programmes.

The specific targets set for the second year of the project were to gather more information about damage to aubergine crops, improve culturing techniques so that insects would be available for experimentation throughout the year, improve our knowledge of the insect's biology and behaviour, develop specialised traps to monitor capsid invasion, and to determine the potential of insect pathogenic fungi for the control of capsids within IPM programmes.

Summary of Results

The first report of capsids in aubergine crops in 1997 was in May when specimens were seen on sticky traps in a crop in East Yorkshire. Detailed monitoring work was concentrated at this site. By mid-June there were two "hot spots" of *L. tripustulatus* activity. Damage

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symptoms included distorted growing points and leaves, and scarred and misshapen fruit. The damage became so severe in late June that the crop was sprayed with a broad spectrum insecticide.

It has proved difficult to rear capsids in the laboratory but cultures are becoming more productive as our knowledge of the insects' biology and behaviour improves. The most successful systems for rearing *L. tripustulatus* are based on the common nettle (*Urtica dioica*) which is a favoured host plant in the insect's natural habitats. Methods of improving the performance of *L. tripustulatus* by providing supplementary food with a high sugar content are being investigated. The most successful systems for rearing *L. rugulipennis* have been based on french bean pods and sprouting potatoes. Cannibalism has been observed in these cultures and this is thought to be one of the main reasons for poor production. The provision of refuges, in which nymphs can seek shelter while moulting, has reduced juvenile mortality and improved overall production. There is an indication that the reproductive rate of *L. rugulipennis* is improved if the diet is supplemented with insect prey and this is being further investigated.

Various types of traps have been tested in commercial crops. Flat and cylindrical versions of white and yellow sticky traps were tested in cucumber and pepper crops known to be infested with *L. rugulipennis* and *L. tripustulatus* respectively. There were no differences between the numbers of capsids caught on the different types of traps. Overall, the numbers of capsids caught were quite small suggesting that the insects were not specifically attracted to them. A series of four experiments reported here, were designed to determine whether traps could be made more attractive by baiting them with live male or female *L. rugulipennis.* Male *L. rugulipennis* were attracted to traps baited with females; thus indicating the production of a sex pheromone. It is hoped that the chemicals will be isolated and formulated in a lure to be tested in traps in cucumber crops in 1998.

The results of bioassays demonstrated that the entomopathogenic fungus, *B. bassiana,* will infect *L. rugulipennis* and *L. tripustulatus* and has potential for the control of both species in commercial crops. However, this strain of *B. bassiana* is active against a wide range of invertebrates and further experimentation is required to determine the overall effect that it may have on whole IPM programmes.

Action points -Recommendations for further research

The project was reviewed on 3 April 1998 and the following recommendations were made for future work:

<u>Monitoring capsid invasion</u> - The team at Stockbridge House should continue to liaise with Paul Innocenzi (PhD student jointly supervised by HRI, East Malling and NRI, University of Greenwich, Chatham) who is isolating the *L. rugulipennis* sex pheromone chemical and formulating a slow release lure for traps. Pheromone baited traps should be evaluated in cucumber crops as soon as possible

Entomopathogenic fungi - Optimum rates of application of *B. bassiana* should be determined for both *L. rugulipennis* and *L. tripustulatus* in plant scale experiments in 1998/99. The entomopathogen should then be evaluated in crop scale experiments in 1999/00.

Insecticides - Bioassays to determine the potential of buprofezin and pymetrozine against both *L. rugulipennis* and *L. tripustulatus* should be completed in 1998/99. If effective, these products should be evaluated in crop scale experiments in 1999/00.

Natural habitats – The team at Stockbridge House should collaborate with ecologists at Newcastle University to gather more information about the natural habitats of *L. rugulipennis* and *L. tripustulatus,* including changes that have occurred in recent years, to explain why they have become such serious problems in glasshouses. Detailed studies of these habitats may identify natural enemies that can be exploited in control programmes.

Practical and financial benefits from study

The provision of robust, sustainable and manageable strategies for the control of capsids in cucumbers, peppers and aubergines will:

1. Avoid direct damage and financial losses caused by these pests.

2. Avoid secondary problems associated with the breakdown of IPM in these crops.

3. Help to satisfy demands of UK's leading food retailers for produce grown under minimal pesticide regimes.

It is anticipated that ornamental crops will also suffer damage from capsids as growers move towards full IPM strategies. Therefore, the acquisition of knowledge and the development of new control measures against these pests will ultimately provide greater benefits within the whole UK horticultural industry.

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EXPERIMENTAL SECTION

INTRODUCTION

Background

Capsid bugs belong to the Miridae; a large family of small to medium sized soft bodied insects which exploit a wide range of diverse habitats. The majority of species are plant feeders but a few are at least partly predatory (eg black-kneed capsid). At least two of the plant feeding species have caused sporadic but important problems in protected salad crops, particularly cucumbers, peppers and aubergines, since the advent of integrated pest management (IPM) programmes.

When pest control strategies were based entirely on chemicals, capsids were inadvertently controlled by treatments applied against other major pests. The removal of routine insecticidal treatments has allowed them to survive, sometimes to cause considerable direct damage and to disrupt whole IPM programmes.

Adult capsids may invade greenhouse crops as early as April but their activity becomes most noticeable in June and July. They and their offspring feed primarily in the growing points of plants and on developing fruits resulting in severe distortion as growth continues. In some situations growing points are completely destroyed and fruit are rendered unmarketable. By the time damage is detected it is usually well advanced and the insects have moved to other parts of the crop.

There are insecticides available which kill capsids but they are not compatible with the biological control agents used to control other pests. Their use can lead to the breakdown of IPM resulting in much wider use of chemicals to control all the other major pests; eg whiteflies, western flower thrips, spider mites and aphids. Furthermore, results with chemicals are often disappointing because it is so difficult to time the treatments correctly.

Commercial objective

The overall objective of this project is to improve the knowledge of the biology and behaviour of plant feeding capsids in protected crops as a first step in formulating a sustainable control strategy within the existing IPM programmes.

Scientific/technical targets of the project

1. A literature search to ensure that the research team have all available information.

2. The pests activity will be monitored at selected sites to improve the knowledge of the species involved, their natural habitats and the timing of crop invasion.

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3. A fact sheet will be prepared aimed at improving grower awareness of the damage caused by capsids.

4. An industry survey will be completed to determine the full extent of the problem in protected edible crops.

5. The information gained from the above tasks will be used to design control strategies based on physical, cultural and/or biological techniques which are compatible with other components in the IPM programme. An additional project will be required to test fully the control methods.

Summary of work completed in Year 1 (Jacobson, 1997)

Detailed crop monitoring at two sites in Yorkshire provided a much improved understanding of capsid problems in cucumbers and peppers but there was still a need for more information about infestations in aubergine crops. No damage was seen or reported in tomatoes. Two species were found to be causing damage; *Lygus rugulipennis* in cucumber crops and *Liocoris tripustulatus* in pepper crops. Detailed examination of vegetation in the immediate vicinity of the infested greenhouses failed to locate important capsid breeding sites. It was therefore assumed that the insects migrate to the greenhouses from other areas.

A total of 120 growers participated in a national survey and 48 confirmed that they had seen capsid activity in their crops. Approximately one third of those who had seen damage, reported that it occurred over large areas of their crops. The most seriously affected were cucumbers where the estimated financial loss ranged from £300 to £2000 per 1000m^2. Many of the growers who reported less serious damage had restricted the development of the problem by applying insecticides but indicated that this had affected biological control of other pests and had resulted in secondary problems.

Approximately 90% of growers who reported damage, had first seen it during the last four years; thus confirming that capsid infestations in cucumbers, peppers and aubergines are recent problems. There were no distinct differences between geographical regions and it was therefore concluded that this was a nationwide problem.

The most effective insecticide used by growers was reported to be propoxur (Fumite Propoxur Smoke) while cypermethrin (Ambush), deltamethrin (Decis), heptenophos (Hostaquick), nicotine (40% Shreds and XL-All Insecticide) and pirimiphos-methyl (Blex and Fumite Pirimiphos-Methyl Smoke) all gave some control. Unfortunately, these are all broad spectrum insecticides and none are compatible with the biological components of the IPM programmes. One grower reported some incidental control of capsids with buprofezin (Applaud) when it was applied against glasshouse whitefly. Buprofezin is compatible with many biological control agents and it's use against capsids should be further investigated.

An illustrated information sheet entitled "Capsid Bugs in Protected Crops" (HDC Fact Sheet 37/96) was produced to provide a guide to the recognition of capsids and symptoms of their damage in cucumbers and peppers.

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Year 2 - Milestones

Following the Project Review Meeting in November 1996, the following targets were agreed for year 2 of the project:

1. More detailed studies at chosen sites will further the knowledge of the pests involved; particularly in aubergine crops identified by the survey in year 1 of the project. The collation of data will be assisted by Mr D Hargreaves and managers of participating nurseries.

2. Improved culturing techniques will be developed to produce sufficient numbers of *L. rugulipennis* and *L. tripustulatus* to enable experiments to continue throughout the year.

3. Laboratory based biological studies will begin to fill important gaps in the knowledge of the biology and behaviour of *L. rugulipennis* and *L. tripustulatus* with particular reference to identifying weak points which may be exploited in control strategies.

4. Work will begin to develop specialised traps to improve the monitoring of capsid invasion and to reduce populations of the pests in crops. The possibility of enhancing the attractiveness of traps by baiting with sex pheromones will be explored. Initially, this will involve the evaluation of traps baited with live unmated insects.

5. Small scale studies will determine by bioassay the efficacy of potentially useful insecticides (such as the insect growth regulator, buprofezin, and the Homoptera specific chemical, pymetrozine) against *L. rugulipennis* and *L. tripustulatus*.

6. Small scale studies will determine by bioassay the efficacy of the insect pathogens, *Verticillium lecanii* and *Beauveria bassiana* against *L. rugulipennis* and *L. tripustulatus*.

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PART 1 – DAMAGE TO AUBERGINE CROPS

A survey of aubergine crops in 1997 revealed the presence of *L. tripustulatus* but not *L. rugulipennis*.

The first report of capsids in aubergine crops in 1997 was in May when specimens were seen on sticky traps in a crop in East Yorkshire. Detailed monitoring work was concentrated at this site. By mid-June there were two "hot spots" of pest activity in the crop with approximately 15 *L. tripustulatus* per plant. Three types of damage were observed:

Growing points:	Some growing points were damaged and this resulted in the distortion of subsequent growth.
Leaf damage:	Feeding on young leaves resulted in distortion and formation of holes as the leaves expanded. This was often associated with damage to growing points. (Figure 1).
Fruit damage:	Damage to young fruit resulted in surface scarring followed by considerable distortion as the fruit swelled. This resulted in misshapen and unmarketable fruit. (Figure 2).

The damage became so severe in late June that the crop was sprayed with a broad spectrum insecticide. This was effective and crop monitoring ceased.

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Figures 1 and 2

PART 2 – CULTURING AND BIOLOGY OF CAPSIDS

Introduction

It has proved very difficult to rear capsids in culture and to maintain supplies of large numbers of insects of known age for use in experiments throughout the year. The author has been in regular contact with two other research groups who are experiencing similar problems (Gillespie, pers. comm.; Innocenzi, pers. Comm.). However, the cultures are becoming more productive as our knowledge of the insects' biology and behaviour improves.

Rearing *Liocoris tripustulatus*

Small scale studies have evaluated the performance of this species on various types of plants and artificial diets. The most successful systems have been based on the common nettle (*Urtica dioica*) which is a favoured host plant in the insect's natural habitats. The nettles are cultivated from root material and a propagation system has been established at Stockbridge House to ensure that good quality plants are available throughout the year. There is an indication that the performance of the insects may be improved by supplementing the diet with artificial foods that have a high sugar content and this is being further investigated.

The life cycle duration of *L. tripustulatus* appears to vary depending on the type and quality of available food. In the nettle based cultures, the life cycle from egg to adult is completed in about 48 days.

Rearing *Lygus rugulipennis*

The most successful systems for rearing *L. rugulipennis* are based on french bean pods and sprouting potatoes. There is an indication that the insect's reproductive rate is improved if the diet is supplemented with invertebrate prey and this is being further investigated. Cannibalism has been observed in the cultures and this is thought to be one of the main reasons for poor production. The provision of refuges, in which nymphs can seek shelter while moulting, has reduced juvenile mortality and improved overall production.

The life cycle, from egg to adult, on potato sprouts and french bean pods is completed in approximately 26 and 45 days respectively. However, adults appear to live longer, lay more eggs and generally perform better on beans than potatoes.

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PART 3 – MONITORING TRAPS

Introduction

Capsid bugs may invade protected crops as early as April but the main migration occurs when populations increase in their natural habitats during the summer. Despite their relatively large size, capsids can be difficult to find in glasshouses and the appearance of damaged growing points and fruit is often the first indication of their presence. Improved monitoring procedures are required to detect capsid invasion and indicate when control measures should be applied.

Various types of traps have been tested in commercial crops. Flat and cylindrical versions of white and yellow sticky traps were tested in cucumber and pepper crops known to be infested with *L. rugulipennis* and *L. tripustulatus* respectively (Figure 3) (Jacobson, 1997). There were no differences between the numbers of capsids caught on the different types of traps. Overall, the numbers of capsids caught were quite small, suggesting that the insects were not specifically attracted to them. It is possible that traps may be made more attractive to the insects by including a sex pheromone lure.

The first evidence of a sex pheromone in Mirid bugs was provided by Scales (1968). He showed that caged virgin females of the tarnished plant bug, *Lygus lineolaris*, attracted males of the same species in substantial numbers. Other studies have demonstrated that male common green capsids (*Lygocoris pabulinus*) are attracted to traps baited with females of the same species (Blommers et al., 1988; Groot et al., 1996). The literature relating to this subject and the chemical identification of the sex pheromones is currently being reviewed by Paul Innocenzi (HRI East Malling).

The series of four experiments reported here were designed to determine whether traps baited with live male or female *L. rugulipennis* would attract insects of the opposite sex; thus indicating the production of a sex pheromone by this species. Insects are extremely vulnerable to heat exhaustion and the first step was to design and test a trap that would contain adult capsids, protect them from direct sun and allow them to remain in good condition throughout the experiment.

Materials and Methods

Sites: Experiment 1: House M20, HRI, Stockbridge House, Yorkshire
Experiment 2: Block A, Cavegate Nurseries, South Cave, Yorkshire
Experiment 3: Block 4, Glen Avon Growers, Cottingham, Yorkshire
Experiment 4: House M22, HRI, Stockbridge House, Yorkshire

Dates: Traps were placed on the following dates:

Experiment 1: 18 July 1997
Experiment 2: 4 August 1997
Experiment 3: 10 August 1997
Experiment 4: 18 August 1997

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Trap design: The traps were a basic delta design, lined with yellow sticky plastic. They contained an upright cylindical tube (125mm x 25mm diameter) with nylon mesh side walls to allow ventilation and the passage of volatile chemicals (Figure 4). Three *L. rugulipennis* were enclosed in each tube and potato shoots were added to provide food.

Trap position: One trap was placed per row of cucumber plants. The traps were suspended among the upper leaves, about 1.8m above the ground, with the open ends in line with the crop rows. They were attached by strings to solid structures to prevent rotation.

Treatments: T1 - Basic delta trap without bait
T2 - Trap baited with potato shoots only
T3 - Trap baited with unmated females
T4 - Trap baited with mated females
T5 - Trap baited with unmated males
T6 - Trap baited with mated males

The treatments included in each experiment are shown in Table 1.

Insects: *L. rugulipennis* were reared in cultures at HRI Stockbridge House. Mated males and females were collected from cultures of mixed sexes. Unmated individuals were collected as nymphs and reared to adults individually.

Assessments: The traps were left in place for 3 days in experiment 2 and for 4 days in experiments 1, 3 and 4. At the end of these periods, the numbers of male and female *L. rugulipennis* captured on the sticky plastic were recorded. The numbers of live *L. rugulipennis* within the cylindrical mesh tubes were also recorded.

Results

The mean numbers of live *L. rugulipennis* within the cylindrical mesh tubes of traps used in each treatment are shown in Table 1. There were always at least two live insects remaining at the end of the experiment and the overall mean was 2.7 per trap.

The mean numbers of *L. rugulipennis* caught per trap per day in each treatment are shown in Table 1. Male *L. rugulipennis* were caught in traps baited with both mated and unmated females. No females were caught in the traps. No *L. rugulipennis* were caught in unbaited traps or in traps baited with males.

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Table 1. Mean numbers of *L. rugulipennis* caught per trap per day in each treatment in four experiments completed in July and August 1997.

Experiment	Treatment (Number of traps)	Mean number of live *L.rugulipennis* in tubes at end of experiment	Mean number of captured *L.rugulipennis* per trap per day:	
			Male	Female
1	T1 – No bait (2)	2.5	0	0
	T3 – Unmated females (2)	2.5	0.25	0
2	T1 – No bait (3)	-	0	0
	T2 – Potato only (3)	-	0	0
	T3 – Unmated females (1)	3	1.33	0
	T4 – Mated females (2)	2	1.83	0
	T5 – Unmated males (1)	3	0	0
	T6 – Mated males (2)	3	0	0
3	T1 – No bait (3)	-	0	0
	T2 – Potato only (3)	-	0	0
	T4 – Mated females (3)	2.7	1.00	0
	T6 – Mated males (3)	2.7	0	0
4	T1 – No bait (3)	-	0	0
	T2 – Potato only (3)	-	0	0
	T4 – Mated females (3)	2.7	0.33	0
	T6 – Mated males (3)	2.7	0	0

Discussion

The results of these experiments show that female *L. rugulipennis* attract males, most probably by means of a sex pheromone.

Certain volatile chemicals produced by female *L. rugulipennis* have since been shown to produce an electroantennogram response by males of the same species (Innocenzi, pers. Comm.). The chemicals are being formulated in a slow release lure and should be available to test in traps in cucumber crops during 1998.

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Figures 3 and 4

PART 4 – CONTROL OF CAPSIDS WITH ENTOMOPATHOGENIC FUNGI

Experiment title:

Evaluation by bioassay of the potential of the entomopathogenic fungi, *Verticillium lecanii* (Mycotal), *V. lecanii* (Vertalec) and *Beauveria bassiana* (Naturalis) for the control of *Lygus rugulipennis* and *Liocoris tripustulatus*.

Introduction

The insecticides currently used to control capsids are not compatible with the biological control agents used to control other pests. Their use leads to the breakdown of IPM which can result in much wider use of chemicals to control whiteflies, western flower thrips, spider mites and aphids. The aim of this work was to identify a biological alternative to broad spectrum insecticides for the control of capsids.

Development of experimental method

Adult capsid bugs are very mobile and it was important to develop a bioassay procedure that would ensure the insects were treated with the test product regardless of their position in the test container.

A series of preliminary experiments were done that evaluated different combinations of various types of sprayer, spray nozzels, concentrations of test products and test containers. In each case, spray solutions were sampled and cultured on selective growth media to determine the initial number of viable spores. Paper discs were placed in five positions within the test container. They were removed immediately after spray application, placed on selective growth media and incubated in the dark at 23°C to determine the distribution of spray deposits in the test container.

An experimental method was selected that ensured the spray reached all parts of the test container without localised flooding.

Materials and Methods

Test container:		A one litre cylindrical glass container with one open end which was covered with a plastic membrane.
Treatments:	T1	Water only.
	T2	0.25g Mycotal per 250ml water (soaked for 3 hours at 20°C prior to treatment).
	T3	0.25g Vertalec per 250ml water (soaked for 3 hours at 20°C prior to treatment).
	T4	1.0ml Naturalis per 250ml water.

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Application: The treatments were applied as a mist produced by a fully calibrated compressed air driven spray gun fitted with a medium nozzle (flat, No. 2). The spray nozzle was fitted in a small hole in the plasic membrane of the test container. The system delivered 1.3ml of spray mixture in 8 seconds.

Insects: *L. rugulipennis* and *L. tripustulatus* were reared in cultures at HRI Stockbridge House. They were tested in batches of five adult females.

The treated insects were removed from the test container immediately after application of sprays, placed in a ventilated culture cage with food material and kept at 21ºC under observation for up to six weeks.

Assessments: Samples were taken from each spray mixture and the number of viable spores determined by culturing on selective growth media.

Insects that died during the post treatment observation period were removed from the culture cage and placed individually on moist filter paper in a Petri dish. Fungal growth that formed on dead insects was sampled, grown on selective growth media and identified.

Results

The effects of the three entomopathogens on *L. rugulipennis* and *L. tripustulatus* are shown in shown in Tables 2 and 3 respectively.

Table 2. Infection of *Lygus rugulipennis* by *V. lecanii* (Mycotal), *V. lecanii* (Vertalec) and *B. bassiana* (Naturalis) in biossays completed in February and March 1998.

Treatment	Number of viable spores per ml of spray mixture	Number of dead test insects within six weeks of treatments	Entomopathogenic fungi confirmed on dead insects
T1 – Water	-	-	-
T2 – Mycotal	4.5×10^6	1	None
T3 – Vertalec	2.3×10^5	5	None
T4 – Naturalis	5.1×10^6	5	*B. bassiana* on 4

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Table 3. Infection of *Liocoris tripustulatus* by *V. lecanii* (Mycotal), *V. lecanii* (Vertalec) and *B. bassiana* (Naturalis) in biossays completed in January and February 1998.

Treatment	Number of viable spores per ml of spray mixture	Number of dead test insects within six weeks of treatments	Entomopathogenic fungi confirmed on dead insects
T1 – Water	-	4	None
T2 – Mycotal	5.0×10^6	4	None
T3 – Vertalec	7.3×10^4	5	None
T4 – Naturalis	5.6×10^6	4	*B. bassiana* on 3

Discussion and Conclusions

The results of the bioassays demonstrated that *B. bassiana* (Naturalis) will infect both *L. rugulipennis* and *L. tripustulatus.* Infected *L. tripustulatus* died within 7 days of treatment while infected *L. rugulipennis* died between 10 and 16 days after spray application.

Neither Mycotal nor Vertalec strains of *V. lecanii* were confirmed to be pathogens of *L. rugulipennis* or *L. tripustulatus*. Fungal growth resembling *V. lecanii* was observed on one dead *L. tripustulatus* when incubated in the Petri dish but this was not confirmed by sampling and growth on selective media.

B. bassiana (Naturalis) has potential for the control of both *L. rugulipennis* and *L. tripustulatus* and should be further evaluated in plant scale experiments. However, this strain of *B. bassiana* is thought to be active against a wide range of invertebrates and it may have additional effects on IPM by infecting other pests and/or beneficial invertebrates used in the IPM programmes.

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RECOMMENDATIONS

The project was reviewed on 3 April 1998 and the following recommendations were made for future work:

Monitoring capsid invasion

It has been demonstrated that female *L. rugulipennis* produce an attractant that is assumed to be a sex pheromone.

It was recommended that the team at Stockbridge House continue to liaise with Paul Innocenzi (PhD student jointly supervised by HRI, East Malling and NRI, University of Greenwich, Chatham) who is isolating the chemical involved and formulating a slow release lure for traps. Pheromone baited traps should be evaluated in cucumber crops as soon as possible. It was considered unlikely that these complex studies would be completed within a single year.

Entomopathogenic fungi

The entomopathogenic fungus, *B. bassiana*, has been shown to infect both *L. rugulipennis* and *L. tripustulatus.*

It was recommended that *B. bassiana* be further evaluated against both *L. rugulipennis* and *L. tripustulatus* in plant scale experiments in 1998/99. The main objective would be to determine rates of application.

The entomopathogen should then be evaluated in crop scale experiments in 1999/00.

Insecticides

Bioassays to determine the potential of buprofezin and pymetrozine against both *L. rugulipennis* and *L. tripustulatus* should be completed in 1998/99.

If effective, these products should be evaluated in crop scale experiments in 1999/00.

Identification of natural enemies

More information is required about the natural habitats of *L. rugulipennis* and *L. tripustulatus,* including changes that have occurred in recent years, to explain why they have become such serious problems. Detailed studies of these habitats may identify natural enemies that can be exploited in control programmes. This topic was discussed at the previous Project Review Meeting (28 November 1996). It was considered to be important but beyond the scope of this project.

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The Project Leader has identified an opportunity for this subject to be addressed through a PhD studentship at Newcastle University. The student would be jointly supervised by HRI and Newcastle University. It was recommended that the studentship be included in this project.

5. General

The work discussed at this Review Meeting will continue for two years beyond the end of the existing contract. It was recommended that the project be extended to accommodate the work.

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