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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.

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PRACTICAL SECTION FOR GROWERS

Background and Objectives

Capsids belong to the Miridae, a large family of small to medium sized soft-bodied insects that exploit a wide range of habitats. For many years, a plant feeding species, *Lygus rugulipennis* (European tarnished plant bug), has been a sporadic pest in U.K. glasshouses but until recently it has been uncommon for specific action to be taken against it in edible crops. When pest control was based entirely on chemicals, invading *L. rugulipennis* did not establish breeding populations on plants because they were killed by insecticides applied against other pests, such as *Trialeurodes vaporariorum* (glasshouse whitefly). With the advent of IPM in protected salad crops in the 1970s and 80s, capsids were able to survive and colonise plants. However, reports of serious damage remained rare until the early-1990s, when the number of requests for advice relating to control of capsids began to increase markedly. In 1996, the HDC commissioned a project aimed at improving the knowledge of the behaviour of plant feeding capsids in protected salads as a first step in formulating a sustainable control strategy within the existing IPM programmes.

Work completed in previous years (1996-97)

The work in the first year of the project concentrated on determining the importance of capsid infestations in protected edible crops. Detailed crop monitoring at several sites in Yorkshire showed that two species were causing damage: *Lygus rugulipennis* in cucumber crops and *Liocoris tripustulatus* in pepper and aubergine crops. The following symptoms were seen in cucumbers, peppers and aubergines: i) feeding in growing points resulted in distorted growth and holes in leaves as they expanded; ii) probing in stems just below growing points resulted in death of the growing point; iii) feeding and egg laying in very young fruit resulted in distortion as the fruit swelled; iv) feeding on maturing fruit resulted in surface scars which rendered the fruit unmarketable. No damage was seen in tomato crops even where they were grown adjacent to heavily infested cucumber and pepper crops.

Based on the detailed monitoring information, an illustrated fact sheet was produced to aid growers recognise capsids and symptoms of their damage (HDC Fact Sheet 37/96) and this was circulated with a questionnaire to all cucumber, pepper and aubergine growers registered with the HDC. A total of 120 cucumber, pepper and aubergine growers responded to the 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 £0.3 to £2 per m^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 that had become much more serious during the last four years.

A reliable method of monitoring the migration of capsid bugs into greenhouses would enable control measures to be more accurately timed. Flat and cylindrical white and yellow traps have been evaluated in cucumber and pepper crops that were infested with *L. rugulipennis*

and *L. tripustulatus* respectively. The numbers of *L. rugulipennis* and *L. tripustulatus* caught were quite small, indicating that the insects were not specifically attracted to any of them. However, the numbers of male *L. rugulipennis* caught were greatly increased when the traps were baited with live females. Volatile chemicals, assumed to be sex pheromones, have now been isolated from female *L. rugulipennis* and are being evaluated as attractants in monitoring traps.

Two commercially available entomopathogenic fungi (*i.e*. two strains of *Verticillium lecanii* [Mycotal and Vertalec], and one product which is currently undergoing registration for use in the UK [Naturalis; *Beauveria bassiana*]), were evaluated against both *L. rugulipennis* and *L. tripustulatus* in laboratory bioassays. *Beauveria bassiana* showed greatest effect.

Specific targets for 1998/99

Following the recommendations of the project review panel in April 1998, HRI formed collaborative links with ecologists at Newcastle University to gather more information about the natural habitats of *L. rugulipennis* and *L. tripustulatus.* This work includes the identification of changes that have occurred in recent years that may explain why capsids have become more common in glasshouses. Studies of the natural habitats may also identify natural enemies that can be exploited in control programmes. The specific targets set for 1998/99 were:

1. To evaluate traps baited with sex pheromones for monitoring the migration of *L. rugulipennis* into protected edible crops. (HRI, Stockbridge House)
2. To evaluate the efficacy of the entomopathogenic fungus, *B. bassiana*, against *L. rugulipennis* on cucumber plants. (HRI, Stockbridge House)
3. To determine the compatability of *B. bassiana* with the predatory mite, *Amblyseius cucumeris*, and the parasitic wasp, *Encarsia formosa*. (HRI, Stockbridge House)
4. To determine the potential of the selective insecticides buprofezin and pymetrozine against *L. rugulipennis*. (HRI, Stockbridge House)
5. To begin to improve the knowledge of the natural habitats of *L. rugulipennis* and *L. tripustulatus*. (Newcastle University)

Summary of Results

It continues to be difficult to rear capsids in culture and maintain supplies of large numbers of insects of known age for use in experiments throughout the year. Other research groups experience similar problems. The cultures at HRI Stockbridge House are becoming much more productive but they occasionally fail due to either poor fecundity or premature death of adults. We have not yet determined the cause of either of these problems. The difficulties most commonly occur during the winter when it is impossible to replenish stocks of insects from natural habitats.

The development of prototype chemical lures was completed in late summer 1998 and their evaluation in protected crops began in September 1998. Cylindrical sticky traps incorporating the lures were constructed and a preliminary evaluation was completed in capsid infested cucumber crops. The results were not conclusive. This may have been because the chemical formulations were incorrect or because the insects were no longer seeking mates at that time of the year. The lures should be available earlier in 1999 and they will be tested when the

second generation of adults becomes active during the summer period.

The entomopathogenic fungus, *B. bassiana*, was evaluated against *L. rugulipennis* on cucumber plants in experimental glasshouses using two methods of application; *i.e.* high volume spray and ultra low volume mist. The methods provided similar results with numbers of adult *L. rugulipennis* being reduced by 60% compared to untreated controls. *Beauveria bassiana* clearly has potential for the control of *L. rugulipennis* both as a HV spray and an ULV mist. The latter is relatively inexpensive because it requires minimal labour. It would allow the cost-effective application of a series of treatments throughout the main *L. rugulipennis* invasion period and is therefore an attractive option. However, further studies are required to determine the optimum frequency and rate of application.

Beauveria bassiana is active against a wide range of invertebrates and it is important to know the impact that it will have on the biological control agents used to control other pests in IPM programmes. The effects of the entomopathogen on the predatory mite, *Amblyseius cucumeris*, and the parasitic wasp, *Encarsia formosa*, were determined in laboratory-based bioassays during 1998/99. There was no evidence to suggest that *B. bassiana* was harmful to *A. cucumeris*, which is consistent with results from another project (HDC Project PC 129) in which populations of *A. cucumeris* on cucumber plants and in culture packs were unaffected by high volume sprays of the entomopathogenic fungus. However, *B.bassiana* was harmful to *E.formosa.* The results of two experiments demonstrated that *B.bassiana* sprayed on parasitised *Trialeurodes vaporariorum* (glasshouse whitefly) scales, before and after they turned black, reduced survival of the parasitoid by 36% and 62% respectively. *Beauveria bassiana* also infects *T. vaporariorum* directly and can provide effective control of this pest, so the overall effect on this component of the IPM programme may not be detrimental.

Pymetrozine is an antifeedant chemical that is specific to some plant-sucking insects of the order Hemiptera. For example, aphids are reported to die due to starvation within 4 days of application of the chemical. It was possible that pymetrozine would be effective against capsid bugs because they are also Hemipterans and this was evaluated in two small scale experiments. Although adult *L. rugulipennis* were not killed by pymetrozine, the damage to the growing points of untreated plants was much greater than in the pymetrozine treatments. This should be further investigated.

The efficacy of the insect growth regulator, buprofezin (Applaud), against *L. rugulipennis* was determined in two small scale experiments. There was no evidence to suggest that buprofezin prevented *L. rugulipennis* nymphs moulting or that it reduced oviposition by adult female *L. rugulipennis*.

The ecology of *L. rugulipennis* and *L. tripustulatus* is not well known. In particular there is little information about where the adult capsids spend the winter months, prior to invading the glasshouses. A survey of potential overwintering sites has commenced. Litter samples (leaves, grass etc.) from HRI Stockbrige House and Close House, the University of Newcastle field station, were collected and examined for the presence of capsids using hand sorting and heat extraction methods. Very low numbers of capsids were retrieved from the litter samples but the studies will continue.

Note on the approval status of the pesticides and entomopathogenic fungi used in the trials

- **Mycotal (*Verticillium lecanii*)**

Use permitted for the control of whitefly in protected cucumber, pepper and aubergine crops.

- **Vertalec (*Verticillium lecanii*)**

Use permitted for the control of aphids in protected cucumber, pepper and aubergine crops.

- **Applaud (buprofezin)**

Use permitted for the control of glasshouse whitefly and tobacco whitefly in protected cucumber, pepper and aubergine crops.

- **Chess (pymetrozine)**

Use is not permitted currently on protected cucumber, pepper or aubergine crops in the UK. Product undergoing registration via the PSD for use on cucumber crops.

- **Naturalis (*Beauveria bassiana* JW-1)**

Use is not permitted currently on protected cucumber, pepper or aubergine crops in the UK. Product undergoing registration via the PSD for use on protected crops.

Action points -Recommendations for further research

The project was reviewed in March 1999 and the following recommendations were made for future work:

Monitoring capsid invasion - The team at HRI Stockbridge House should continue to liaise with Paul Innocenzi (PhD student jointly supervised by HRI, East Malling and NRI, University of Greenwich, Chatham) to evaluate traps baited with the slow release chemical lure for traps.

Entomopathogenic fungi – The efficacy of *B.bassiana* against *L. rugulipennis* should be further evaluated in plant scale experiments in 1999, with particular emphasis on ULV treatments. The effect of *B.bassiana* on the predatory mite, *Phytoseiulus persimilis*, and the parasitoid, *Aphidius colemani*, should be determined.

Insecticides – The reduction of damage to cucumber plants following application of the antifeedant, pymetrozine, should be further investigated.

Natural habitats – Work on the culturing and bionomics of *L. rugulipennis* and *L. tripustulatus* should be continued. Further studies of potential overwintering sites should be carried out in 1999/2000 in light of the results from 1999 summer field sampling.

Practical and financial benefits from the 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.

SCIENCE SECTION

Introduction

Background

Capsids belong to the Miridae, a large family of small to medium sized soft-bodied insects that exploit a wide range of habitats. For many years, a plant feeding species, *Lygus rugulipennis* (European tarnished plant bug), has been a sporadic pest in UK glasshouses (Wardlow, 1985) but until recently it has been uncommon for specific action to be taken against it in edible crops. When pest control was based entirely on chemicals, invading *L. rugulipennis* did not establish breeding populations on plants because they were killed by insecticides applied against other pests, such as *Trialeurodes vaporariorum* (glasshouse whitefly). With the advent of IPM in protected salad crops in the 1970s and 80s, capsids were able to survive and colonise plants. However, reports of serious damage remained rare until the early-1990s, when the number of requests for advice relating to control of capsids began to increase markedly. In 1996, the Horticultural Development Council (HDC) commissioned a project aimed at improving the knowledge of the behaviour of plant feeding capsids in protected salads as a first step in formulating a sustainable control strategy within the existing IPM programmes.

Scientific/technical targets of the project

Years 1 and 2 (1996-1998)

1. A literature search to ensure that the research team has all available information.
2. The pest's activity will be monitored at selected sites to improve the knowledge of the species involved, their natural habitats and the timing of crop invasion.
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.

Years 3 to 5 (1998-2001)

In 1998, the project was extended to encompass the following additional targets:

5. To improve the knowledge of the biology and behaviour of *Lygus rugulipennis* and *Licoris tripustulatus*, with particular reference to their activity in protected edible crops.
6. To develop methods of monitoring the invasion of protected edible crops by capsids.
7. To develop methods of controlling *L. rugulipennis* and *L. tripustulatus* within IPM programmes in protected edible crops.
8. To study the natural habitats of *L. rugulipennis* and *L. tripustulatus* and identify factors that have changed their status as pests.
9. To identify possible measures that may reduce the invasion of *L. rugulipennis* and *L. tripustulatus* into glasshouses.
10. To identify natural enemies of *L. rugulipennis* and *L. tripustulatus* that may be exploited in IPM programmes in glasshouses.

Summary of work completed in Years 1 and 2 (Jacobson, 1997; Jacobson, 1998)

During 1996 and 1997, cucumber, tomato, pepper and aubergine crops were monitored at sites that had suffered intermittent damage by capsids in recent seasons. Two species of capsids were found to be causing damage; *Lygus rugulipennis* in cucumbers and *Liocoris tripustulatus* in peppers and aubergines. No damage was seen in tomato crops even where they were grown adjacent to heavily infested cucumber and pepper crops. The following symptoms were seen in cucumbers, peppers and aubergines:

i) capsid feeding in growing points resulting in distorted growth and holes in leaves as they expanded
ii) capsid probing in the stem just below the growing point resulting in death of the growing point
iii) capsid feeding and egg laying in very young fruit resulting in distortion as the fruit swelled
iv) capsid feeding on maturing fruit resulting in surface scars which rendered the fruit unmarketable.

Based on the detailed monitoring information, an illustrated fact sheet was produced to aid growers recognise capsids and symptoms of their damage (Jacobson & Hargreaves, 1996). In March 1997, this fact sheet was circulated with a questionnaire to all cucumber, pepper and aubergine growers registered with the HDC. Of 120 growers who responded to the survey, 48 confirmed that they had seen capsid activity and approximately one third of those reported that it occurred over large areas of their crops. The most seriously affected were cucumbers where the estimated financial loss ranged from £0.3 to £2 per m^2. Many growers who reported less serious damage had restricted the development of capsid infestations by applying insecticides but indicated that this disrupted IPM and resulted in secondary problems with other pests. The reported occurrences of *L. rugulipennis* in cucumber crops indicated that there was a small invasion in late-spring followed by a much larger invasion in July. This is consistent with the described bivoltine life cycle (Southwood, 1956; Easterbrook, 1997). The activity of *L. tripustulatus* was more evenly spread between May and September. Approximately 90% of growers who reported damage by capsids, had first seen it during the last five years; thus confirming that infestations were becoming more common in protected salad crops. There were no distinct differences between geographical regions showing this to be a national problem. Detailed examination of vegetation in the immediate vicinity of infested glasshouses failed to identify important breeding sites, so it must be assumed that both species migrate to the glasshouses from other locations. It is unclear why capsids should have become more troublesome in cucumbers, peppers and aubergines in recent years. It is unlikely that the behaviour of the two species has simultaneously changed, so it is probably due to differences in the availability of plant food or natural habitats. As there has been no widespread change in crop husbandry or insecticide usage that could have allowed capsids a new opportunity to colonise these crops, the most probable explanation is a change in their natural habitats outside the glasshouses leading to larger invasions.

A reliable method of monitoring the migration of capsid bugs into greenhouses would enable control measures to be timed more accurately. In 1996, flat and cylindrical white and yellow traps were evaluated in cucumber and pepper crops that were infested with *L. rugulipennis* and *L. tripustulatus* respectively. The numbers of *L. rugulipennis* and *L. tripustulatus* caught

were quite small, indicating that the insects were not specifically attracted to any of them. However, the numbers of male *L. rugulipennis* caught were greatly increased when the traps were baited with live conspecific females. Volatile chemicals, assumed to be sex pheromones, have now been isolated from female *L. rugulipennis* and are being evaluated as attractants in monitoring traps (Innocenzi *et al*., 1998).

Three commercially available entomopathogenic fungi (*i.e*. two strains of *Verticillium lecanii* [Mycotal and Vertalec] and one *Beauveria bassiana* [Naturalis]) were evaluated against both *L. rugulipennis* and *L. tripustulatus* in laboratory bioassays. Naturalis showed greatest effect and was evaluated against *L. rugilipennis* in a glasshouse experiment in 1998.

Year 3 – Work plan

Following the Project Review Meeting in April 1998, the following work plan was agreed for year 3 of the project:

1. To evaluate traps baited with sex pheromones for monitoring the migration of *L. rugulipennis* in to protected edible crops. (HRI, Stockbridge House)
2. To evaluate the efficacy of the entomopathogenic fungus, *B. bassiana*, against *L. rugulipennis* on cucumber plants. (HRI, Stockbridge House)
3. To determine the compatability of *B. bassiana* with the predatory mite, *Amblyseius cucumeris*, and the parasitic wasp, *Encarsia formosa*. (HRI, Stockbridge House)
4. To determine the potential of the selective insecticides buprofezin and pymetrozine against *L. rugulipennis*. (HRI, Stockbridge House)
5. To begin to improve the knowledge of the natural habitats of *L. rugulipennis* and *L. tripustulatus*. (Newcastle University)

PART 1 – CULTURING CAPSIDS

Introduction

It continues to be difficult to rear capsids in culture and maintain supplies of large numbers of insects of known age for use in experiments throughout the year. Other research groups experience similar problems (Gillespie, pers. com.; Innocenzi, pers. com.). The cultures at HRI Stockbridge House are becoming more productive but they occasionally fail due to either poor fecundity or premature death of adults. We have not yet determined the cause of either of these problems. The difficulties most commonly occur during the winter when it is impossible to replenish stocks of insects from natural habitats and this can have a serious impact on the experimental programme.

Rearing *Lygus rugulipennis*

The most successful systems for rearing *L. rugulipennis* are based on french bean pods and/or sprouting potatoes. The rearing system at HRI Stockbridge House uses the latter. Several stock cultures are maintained and these contain all life cycle stages. Cannibalism, which has been observed in the cultures, is reduced by the provision of refuges in which nymphs can shelter while moulting. In addition, there is continuous production of synchronised cultures in which all insects are within two days of the same age. These insects can be harvested at any life cycle stage for use in experiments.

Rearing *Liocoris tripustulatus*

This species is reared 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. The performance of the insects appears to be improved by supplementing the diet with some invertebrate prey and this is being further investigated. In the interim, small infestations of aphids are maintained on the plants in the culture. Both stock cultures and synchronised cultures are maintained throughout the year.

PART 2 – DEVELOPMENT OF METHODS OF MONITORING CAPSID INVASION

Experiment title:

Preliminary evaluation of pheromone baited sticky traps against *Lygus rugulipennis* on cucumber plants.

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.

The present experiment was designed to determine whether traps baited with volatile chemicals, assumed to be sex pheromones, produced by female *L. rugulipennis* (Innocenzi, 1998) would attract males of the same species. The development of prototype chemical lures was completed by Paul Innocenzi in late summer 1998 and their evaluation in protected crops began in September.

Materials and Methods

Sites:
1. Glasshouse FF 2, HRI, Stockbridge House.
   Crop description - Cucumber plants approx 1.5m tall but with variable height due to capsid damage to growing points.
2. Section 2, Headley Hall Glasshouse Complex, HRI, Stockbridge House.
   Crop description - Cucumber plants approx 1.8m tall but with variable height due to capsid damage to growing points.
3. Field L2, HRI, Stockbridge House.
   Crop description – Weed trial with plots containing very large numbers of *Chenopodium album* (fat hen), a favoured host of *L. rugulipennis*.

Insects: Large numbers of *L. rugulipennis* present at all sites.

Treatments:
1. Unbaited trap
2. Trap baited with one lure containing 200 µl hexyl butyrate, (E) -2-hexenyl butyrate and (E)-4-oxo-2-hexenal (135:55:10)

Trap design and position: Each trap was based on an Agralan yellow sticky trap (20 x 25 cm), curled and stapled into a cylindrical shape, with the lure enclosed in a nylon mesh (0.5mm) envelope stapled to the lower edge. The whole trap was either suspended from crop wires (in glasshouses) or fastened to wooden posts in the ground (outdoor plots). In both cases, the traps were positioned just above the top of the plants. Two baited and two unbaited traps were placed at each site. The positions were alternated daily.

Assessment: Numbers of male and female *L. rugulipennis* on traps recorded daily during the periods shown in table 1.

Results:

The total numbers of *L. rugulipennis* recorded on traps at the three monitored sites are shown in Table 1. The sample size was too small to allow the data to be analysed statistically but there were no consistent differences between numbers of males or females on traps at any of the sites.

Table 1. Total numbers of male and female *L. rugulipennis* caught on baited and unbaited traps at three sites during September and October 1998.

Site	Period traps monitored	Trap type	Cumulative of *L. rugulipennis*:	
			Male	Female
1. Cucumbers	17/9 to 9/10	Baited	11	15
		Unbaited	12	14
2. Cucumbers	29/9 to 6/10	Baited	0	0
		Unbaited	1	1
3. Field	22/9 to 8/10	Baited	4	2
		Unbaited	5	2

Discussion and Conclusions:

There was no evidence to suggest that the combination or concentration of chemicals used in the lures in this experiment increased the attractiveness of the sticky traps to either male or female *L. rugulipennis*. However, this is not consistent with the results of laboratory studies that tested the same chemical formulation (Innocenzi, pers. com.). It is possible that different formulations are required to be effective on a large scale. This is being further investigated and the results will influence the design of experiments in 1999. It is also possible that the lures failed to attract *L. rugulipennis* because it was late in the year and the insects were no longer seeking mates. The lures should be available earlier in 1999 and they will be tested when the second generation of adults becomes active during the summer period.

PART 3 – CONTROL OF CAPSIDS WITH *BEAUVERIA BASSIANA*

Experiment title:

To evaluate *Beauveria bassiana* against *Lygus rugulipennis* on cucumber plants.

Introduction:

Laboratory-based bioassays completed in 1998, demonstrated that *B. bassiana* (Naturalis) had the potential to control *L. rugulipennis* but this required confirmation in glasshouse experiments. Two methods of applying the entomopathogen were included in the present experiment; *i.e.* high volume spray and ultra low volume mist. The latter was applied through a Turbair Scamp 240, which was chosen because the machine's output was suitable for the relatively small experimental glasshouses. Preliminary studies, using water sensitive paper pinned in various positions throughout the glasshouse, determined the most appropriate volume of liquid to apply through the Turbair. Additional tests compared the number of viable spores in the *B. bassiana* suspension in the spray tank with the number in the spray as it emerged from the spray nozzle. The action of the Turbair did not affect the number or viability of the spores.

Materials and methods:

Site: HRI, Stockbridge House

Glasshouse: Headley Hall Glasshouse Unit

Treatments:
1. Untreated control
2. 400m1 Naturalis/l00l water applied high volume (Recommended rate)
3. 12 ml Naturalis per 290ml water per 109m^3 applied ultra low volume.
4. 22 ml Naturalis per 280ml water per 109m^3 applied ultra low volume.

Application: Treatments were applied on 21 September 1998 when the plants were about 1.75m tall. The high volume sprays were applied to maximum leaf retention using a fully calibrated Oxford Precision Sprayer. The rate of application was equivalent to approximately 1350 litres per hectare. The ultra low volume treatments were applied using a fully calibrated Turbair Scamp 240.

Crop: Cucumber, cv Enigma

Sowing date: 10 August 1998

Planting date: 28 August 1998

Growing medium: The plants were grown in peat bags with excess feed solution running to waste and were trained by the cordon-V system.

Expt design: The experiment was designed with Mr John Fenlon (Biometrician, HRI, Wellesbourne). Due to the pest's mobility, each treatment was confined to a separate glasshouse section. Whole treatments were not replicated but each section contained twenty four plants arranged in four plots.

Pest infestation: Adult *L. rugulipennis* were collected from natural habitats between 4 and 10 September 1998 and released in equal numbers in each of the glasshouse sections.

Assessments:

1. Samples were taken from each spray mixture and the number of viable *B. bassiana* spores determined by culturing on growth media.

2. The numbers of *L. rugulipennis* per plant were determined in each glasshouse unit immediately before application of treatments and 7 days after application of treatments. The assessments were done in the early morning when the insects were least active. On each occasion, alternate plants were examined carefully, working from bottom to top, with particular attention given to growing points, side shoots and flowers.

3. Dead *L. rugulipennis* were collected and placed on damp filter paper in Petri dishes and incubated without light at 23^0C. Fungal growth on dead insects was subsequently sub-cultured on growth media, incubated until sporulation occurred and identified.

4. The temperature and humidity in the glasshouses were recorded throughout the experiment.

Analysis of data: Data from the first assessment was analysed by analysis of variance and differences compared using LSD. The second assessment was analysed similarly but using the first assessment as a covariate. Some caution is required when interpreting the results from experiments such as this, where it is impractical to fully replicate treatments. There is no true replication and within treatment variation is used as a measure for experimental variation.

Results

The HV spray mixture contained 9.8 x 10^4 viable *B. bassiana* spores per ml. The spray mixtures used in the lower and higher rates of ULV application contained 2.0 x 10^6 and 5.4 x 10^6 viable *B. bassiana* spores per ml respectively.

The mean numbers of adult *L. rugulipennis* per plant in each treatment, on each assessment date, are shown in Table 2. Before *B. bassiana* was applied, there were significantly more *L. rugulipennis* on the plants in the lower rate ULV treatment (Treatment 3) than on the plants in the other three treatments. The data from the post-application assessment were therefore analysed by covariance, which showed that there was no significant difference in the numbers

of *L. rugulipennis* on plants in the three *B. bassiana* treatments but all were significantly lower than the untreated control ($P<0.05$). The presence of *B. bassiana* was confirmed on dead *L. rugulipennis* that were collected on 28 September 1998.

The mean temperature during the experimental period was 18.9°C . The relative humidity recorded in the crop canopy between 21 and 28 September 1998 is shown in Figure 1.

Table 2. Mean numbers of adult *L. rugulipennis* per plant in each treatment, on 21 September 1998 and 28 September 1998.

Treatments	Mean number of *L.rugulipennis* adults per plant:		
	Before application of *B.bassiana*	Seven days post-application of *B.bassiana*	Adjusted post-application means
1.Untreated control	2.00	1.75	1.94
2. Naturalis - high volume	2.75	0.67	0.65
3. Naturalis – ulv lower rate	3.67	1.33	1.06
4. Naturalis – ulv higher rate	2.33	0.42	0.52
LSD (df = 12)	1.47	0.71	0.62

Discussion and Conclusion

The overall mean number of adult *L. rugulipennis* in the *B. bassiana* treatments was approximately 60% lower than the untreated control. This level of control is broadly consistent with that recorded when *B. bassiana* was applied against *Lygus lineolaris* on cotton in the USA and against *Lygus hesperus* in laboratory studies at the University of Idaho (Brown, pers. com.).

The relative humidity in the glasshouse was relatively high during the experiment, which favours the development of fungal entomopathogens. The experiment therefore should be repeated under conditions of lower relative humidity.

Beauveria bassiana clearly has potential for the control of *L. rugulipennis* both as a HV spray and an ULV mist. The latter is relatively inexpensive because it requires minimal labour. It would allow the cost-effective application of a series of treatments throughout the main *L. rugulipennis* invasion period and is therefore an attractive option. However, further studies are required to determine the optimum frequency and rate of application.

Insert Figure 1.

PART 4 – COMPATABILITY OF *BEAUVERIA BASSIANA* WITH *ENCARSIA FORMOSA*

Introduction:

If *B. bassiana* is to be incorporated in the cucumber IPM programme, it is important to know the impact that it will have on the biological control agents used to control other pests.

Encarsia formosa is a well known and commonly used parasitoid of *Trialeurodes vaporariorum* (glasshouse whitefly). It is released routinely in cucumber crops and is an important component of the IPM programme. *Trialeurodes vaporariorum* has six immature stages; *i.e.* egg, four larval instars and pupae. The larvae and pupae are commonly called scales. Although the adult wasp can lay her eggs in any of the four larval instars of *T. vaporariorum*, she prefers the third and fourth because this gives her offspring the greatest chance of successful development. Parasitism can be easily recognised in the latter stages of the immature wasp's development because the *T. vaporariorum* pupa turns black.

This study was done in two parts. The first experiment was designed to determine the effect of application of *B.bassiana* on *E. formosa* in fourth instar *T. vaporariorum* larvae that had not yet turned black. The second experiment determined the effect of *B.bassiana* on *E. formosa* at a later stage of their development, *i.e.* after the pupae had turned black.

Experiment 1 - Title:

Effect of *Beauveria bassiana* on immature *Encarsia formosa* prior to the host whitefly scale turning black.

Materials and Methods:

Insects: Synchronised population of *E. formosa* in fourth instar *T. vaporariorum* larvae (scales) that had not yet turned black.

Plants: Tobacco

Treatments:
1. Untreated control
2. Sprayed with water
3. Sprayed with *B. bassiana* at the rate of 4ml product (Naturalis) per litre of water.

Application: Tobacco leaves were cut into pieces, each with approximately 800 parasitised *T. vaporariorum* scales. The sprays were applied to these leaf pieces to the point of maximum leaf retention using a Hozelock sprayer. Each piece of leaf was allowed to dry naturally and then transferred to a large ventilated Petri dish.

Environment: All Petri dishes were placed in an incubator at 21°C and 16L:8D for the duration of the experiment.

Experimental Design: Each Petri dish formed a replicate and there were ten replicates per treatment.

Asssessment:

1. Samples were taken from each spray mixture and the number of viable *B. bassiana* spores determined by culturing on growth media.

2. Eleven days after application of sprays, unparasitised *T. vaporariorum* had emerged as adults and parasitised *T. vaporariorum* scales had turned black. Four points were chosen at random on each leaf and the closest fifty *T. vaporariorum* scales to each point were examined, ensuring that there was no overlap between samples. The following were recorded:
   i) numbers of dead *T. vaporariorum* scales
   ii) numbers of scales from which adult *T. vaporariorum* had emerged
   iii) numbers of black scales

3. Seventeen days after application of sprays, adult *E. formosa* had emerged from black scales. Four points were chosen at random on each leaf and the closest fifty black *T. vaporariorum* scales to each point were examined, ensuring that there was no overlap between samples. The following were recorded:
   i) numbers of scales from which adult *E. formosa* had emerged
   ii) numbers of black scales in which *E. formosa* had died

Analysis of Data: Analysis of variance and differences compared using LSD.

Results:

The HV spray mixture contained 1.4 x 10^5 viable *B. bassiana* spores per ml.

Table 3 shows the mean numbers of live and dead *T. vaporariorum* and *E.formosa*, recorded 11 and 17 days after application of *B.bassiana*, compared to controls that were either untreated or sprayed with water.

Eleven days after spray application, the numbers of dead white scales were greater in the *B.bassiana* treatment than in the water treatment, which in turn were greater than the untreated control ($P<0.05$). At the same time, numbers of black scales were greater in the untreated controls than in the water treatment, which were greater than the *B.bassiana* treatment ($P<0.05$).

Seventeen days after spray application, the numbers of *E. formosa* that emerged from black scales in the water treatment and the untreated control were similar, but fewer emerged in the *B. bassiana* treatment ($P<0.05$).

Table 3. The mean numbers of live and dead *T. vaporariorum* and *E.formosa* recorded 11 and 17 days after application of *B.bassiana*, compared to controls that were either untreated or sprayed with water.

Treatment	11 days post-spray application (n=200)			17 days post-spray application (n=200)
	Dead white scales	Emerged adult whitefly	Black scales	*Encarsia* emerged from black scales
1. Untreated control	52a	27a	121a	143 ab
2. Water spray	113b	12b	75b	148 a
3. *B.bassiana* spray	140c	4c	56c	130 b
	Within each column, numbers followed by different letters are significantly different (P<0.05)			

Discussion and Conclusion:

Application of *B.bassiana* to a population of parasitised fourth instar *T. vaporariorum* larvae significantly reduced the number of adult *E. formosa* that subsequently emerged from the black scales. To quantify the effect of the entomopathogenic fungus on the parasitoid, the emergence figures must be corrected to allow both for the proportion of *T. vaporariorum* larvae that were unparasitised and for natural mortality. Taking these factors into account, it is estimated that the application of *B. bassiana* reduced the survival of *E. formosa* by approximately 36%.

Experiment 2 - Title:

Effect of *Beauveria bassiana* on immature *Encarsia formosa* after the host whitefly scale has turned black.

Materials and Methods:

Insects: Synchronised population of *E. formosa* in *T. vaporariorum* pupae (scales) that have turned black.

Plants: Tobacco

Treatments:
1. Untreated control
3. Sprayed with water
3. Sprayed with *B. bassiana* at the rate of 4ml product (Naturalis) per litre of water.

Application: Tobacco leaves were cut into pieces, each with 200-300 parasitised *T. vaporariorum* scales. The sprays were applied to these leaf pieces to the point of maximum leaf retention using a Hozelock sprayer. Each piece of leaf was allowed to dry naturally and then transferred to a large ventilated Petri dish.

Environment: All Petri dishes were placed in an incubator at 21°C and 16L:8D for the duration of the experiment.

Experimental Design: Each Petri dish formed a replicate and there were five replicates per treatment.

Asssessment:

1. Samples were taken from each spray mixture and the number of viable *B. bassiana* spores determined by culturing on growth media.

2. Nine days after application of sprays, adult *E. formosa* had emerged from black scales. Four points were chosen at random on each leaf and the closest twenty five black *T. vaporariorum* scales to each point were examined, ensuring that there was no overlap between samples. The following were recorded:
   i) numbers of scales from which adult *E. formosa* had emerged
   ii) numbers of black scales in which *E. formosa* had died

Analysis of Data: Analysis of variance and differences compared using LSD.

Results:

The HV spray mixture contained 1.4 x 10^5 viable *B. bassiana* spores per ml. The mean numbers of live and dead *E.formosa*, recorded 9 days after application of *B.bassiana*, compared to controls that were either untreated or sprayed with water, are shown in Table 4. The numbers of *E. formosa* that emerged from black scales were greater in the untreated controls than in the water treatment, which in turn were greater than the *B.bassiana* treatment ($P<0.05$).

Table 4. Mean numbers of live and dead *E.formosa*, recorded 9 days after application of *B.bassiana*, compared to controls that were either untreated or sprayed with water.

Treatment	Mean numbers of black scales for which:	
	no *E. formosa* emerged	*E. formosa* emerged
1. Untreated control	14	86
2. Water spray	21	79
3. *B.bassiana*	70	30
	Within each column, all figures are significantly different ($P<0.05$).	

Discussion and Conclusion:

Application of *B.bassiana* to a population of parasitised *T. vaporariorum* pupae, significantly reduced the number of adult *E. formosa* that subsequently emerged from the black scales. To quantify the effect of the entomopathogenic fungus on the parasitoid, the emergence figures must be corrected to allow for natural mortality during the experiment. Taking this into account, it is estimated that the application of *B. bassiana* reduced the survival of *E. formosa* by approximately 62%.

The combined results of the two experiments demonstrate that spray applications of *B.bassiana* are harmful to immature *E. formosa* when applied to parasitised *T. vaporariorum* scales both before and after they turn black. Survival of the parasitoid may be reduced by 36% or 62% depending on the insect's stage of development when *B. bassiana* is applied. However, *B. bassiana* also infects *T. vaporariorum* and can provide effective control of this pest so the overall effect on this component of the IPM programme may not be detrimental.

PART 5 – COMPATABILITY OF *BEAUVERIA BASSIANA* WITH *AMBLYSEIUS CUCUMERIS*

Experiment title:

Compatibility of *Beauveria bassiana* with *Amblyseius cucumeris*.

Introduction:

The predatory mite, *Amblyseius cucumeris*, has formed the basis of the control of *Frankliniella occidentalis* (western flower thrips) in cucumber, pepper and aubergine crops for several years and it is an extremely important component of the IPM programmes. The predators are introduced in culture packs that remain active in the crop for several weeks (Jacobson, 1995).

Materials and Methods:

Mites: Separate populations of the predatory mites, *A. cucumeris,* and the stored product mite, *Tyrophagus* spp., upon which the predator is reared, were obtained from a commercial biocontrol production company.

Plants: Cucumber, cv Enigma

Treatments:
1. Untreated control
2. Sprayed with water
3. Sprayed with *B. bassiana* at the rate of 4ml product (Naturalis) per litre of water.

Application: The cucumber leaves were cut into pieces that would fit in a 90 mm Petri dish. The sprays were applied to these leaf pieces to the point of maximum leaf retention using a Hozelock sprayer. Each piece of leaf was allowed to dry naturally and then transferred to a non-ventilated dish.

Procedure: Twenty *A.cucumeris* adults were placed on each piece of leaf. After about fifteen minutes, approximately 0.8 ml of cereal-based culture material containing *Tyrophagus* spp. were placed in the dish.

Environment: All Petri dishes were placed in an incubator at 23°C and 16L:8D for the duration of the experiment. They were examined daily and additional prey mites were added if required.

Experimental Design: Each Petri dish formed a replicate and there were ten replicates per treatment.

Asssessment:
1. Samples were taken from the spray mixture and the number of viable *B. bassiana* spores determined by culturing on growth media.

2. Seven days after spray application, the numbers of *A. cucumeris* adults

and nymphs in each replicate were recorded.

Analysis of Data: Analysis of variance and LSD.

Results:

The HV spray mixture contained 1.4 x 10^5 viable *B. bassiana* spores per ml. The mean numbers of *A. cucumeris* adults and nymphs recorded in each treatment, seven days after application of *B.bassiana*, are shown in Table 5. There were no significant differences between treatments.

Table 5. Mean numbers of *A. cucumeris* adults and nymphs recorded in each treatment, seven days after application of *B.bassiana.*

Treatment	Mean number of live *A. cucumeris*:	
	adults	nymphs
1. untreated control	5.7	21.9
2. water spray	8.5	27.9
3. *B.bassiana* spray	6.6	29.9
	The figures within each column are not significantly different	

Discussion and Conclusion:

There was no evidence to suggest that *B. bassiana* was harmful to the predatory mite, *A. cucumeris*. This is consistent with results from another project (PC 129) in which populations of *A. cucumeris* on cucumber plants and in culture packs were unaffected by high volume sprays of the entomopathogenic fungus.

PART 6 – CONTROL OF *LYGUS RUGULIPENNIS* WITH PYMETROZINE

Experiment title:

To evaluate pymetrozine against *Lygus rugulipennis* on cucumber plants.

Introduction:

The antifeedant chemical, pymetrozine (Chess), is specific to some plant-sucking insects of the order Hemiptera. Aphids are reported to die due to starvation within 4 days. The product (Chess) has been submitted to the PSD for registration in the UK for use on protected cucumber crops. This product could be integrated into the IPM programme for cucumbers. Capsid bugs also belong to the order Hemiptera and could be susceptible to pymetrozine.

This preliminary study was designed to determine whether pymetrozine caused mortality of *L. rugulipennis* directly or indirectly through antifeedant properties. There were two similar experiments; the first was done in December 1998 and the second in January 1999.

Materials and Methods:

Site: HRI, Stockbridge House, Glasshouse F14

Insects: Insects reared in culture at HRI Stockbridge House

Plants: Cucumber (cv Enigma [Expt 1] and cv Sabrina [Expt 2]) plants with 4-5 true leaves, grown in peat in rockwool blocks.

Treatments:
1. Untreated control – *L. rugulipennis* without food
2. Untreated control – *L. rugulipennis* on untreated cucumber plants
3. *L. rugulipennis* sprayed with pymetrozine in vitro and then placed on untreated cucumber plants
4. *L. rugulipennis* placed on cucumber plants that had been sprayed with pymetrozine

Application: Pymetrozine was applied at the rate of 40g product per 100 litre water. In treatment 3, *L. rugulipennis* were temporarily "knocked out" with CO^2, placed on a cucumber leaf and sprayed to maximum leaf retention using a Hozelock sprayer before being transferred to untreated plants. In treatment 4, plants were sprayed to maximum leaf retention using a Hozelock sprayer and allowed to dry naturally before *L. rugulipennis* were transferred on to them.

Environment: Following spray application the insects and/or plants were placed in perspex cages and maintained at $22^{O}C$ +/- $4\ ^{O}C$ with supplementary light to provide 16:8 L:D. Refuges consisting of crumpled tissue paper were provided in each cage.

Experimental

design: One replicate per treatment with 14 adult *L. rugulipennis* per replicate.

Assessment: The cages were examined daily and the number of live and dead *L. rugulipennis* recorded.

Analysis of Data: Formal analysis of the data was not possible.

Results and Discussion:

The mortality of *L. rugulipennis* in all treatments in experiments 1 and 2 is shown in Tables 6 and 7 respectively. The insects that were deprived of food in Treatment 1 died within two to three days. Pymetrozine applied directly to *L. rugulipennis* (Treatment 3) or via the host plant (Treatment 4) did not appear to affect the survival of the insects compared to the untreated *L. rugulipennis* that were supplied with food (Treatment 2).

Although pymetrozine did not kill *L. rugulipennis*, the damage to the growing points of the plants in the untreated controls (Treatment 2) was observed to be greater than in the pymetrozine treatments. This could be due to reduced feeding and will be further investigated in 1999/2000.

Table 6. Mortality of *L. rugulipennis* in four treatments in Experiment 1.

Treatment	Percentage mortality at day:				
	1	2	5	6	11/12
1. No food	50	100	100	100	100
2. Untreated, + food	21	21	21	29	71
3. Sprayed insects	14	21	21	14	79
4. Sprayed plants	14	14	14	29	79

Table 7. Mortality of *L. rugulipennis* in four treatments in Experiment 2.

Treatment	Percentage mortality at day:				
	1	2	3	8	11
1. No food	25	83	100	100	100
2. Untreated, + food	8	15	15	31	54
3. Sprayed insects	15	31	31	31	31
4. Sprayed plants	25	31	31	31	31

PART 7 – CONTROL OF *LYGUS RUGULIPENNIS* WITH BUPROFEZIN

Introduction:

Buprofezin (Applaud) is an insect growth regulator that kills immature insects by disrupting chitin production when they moult. It is also claimed to reduce the fecundity of adult insects. It is a selective insecticide, which is effective against specific species of the order Homoptera, including whiteflies and leaf hoppers, and it can be integrated in the cucumber IPM programme. One grower who responded to the 1997 survey, reported some incidental control of *L. rugulipennis* when buprofezin was applied against a population of glasshouse whitefly.

This study included two experiments. The first determined the effect of buprofezin on *L. rugulipennis* nymphs and the second determined the effect on oviposition by adult *L. rugulipennis*.

Experiment 1 - Title:

To evaluate buprofezin against *Lygus rugulipennis* nymphs on cucumber plants.

Materials and Methods:

Site: HRI, Stockbridge House, Glasshouse F14

Insects: Third instar *L. rugulipennis* nymphs reared on potato in cultures at HRI Stockbridge House and conditioned to cucumber plants for two days before the experiment began.

Plants: Cucumber (cv Enigma) plants with 4-5 true leaves, grown in peat in rockwool blocks.

Treatments:
1. Untreated control – *L. rugulipennis* on untreated cucumber plants.
2. *L. rugulipennis* sprayed with buprofezin in vitro and then placed on untreated cucumber plants
3. *L. rugulipennis* placed on cucumber plants that had been sprayed with buprofezin

Application: Buprofezin was applied at the rate of 30g product per 100 litre water. In treatment 2, *L. rugulipennis* were temporarily "knocked out" with CO^2, placed on a cucumber leaf and sprayed to maximum leaf retention using a Hozelock sprayer before being transferred to untreated plants. In treatment 3, plants were sprayed to maximum leaf retention using a Hozelock sprayer before *L. rugulipennis* were transferred on to them.

Environment: Following treatment the insects and plants were placed in perspex cages and maintained at 22^{O}C +/- 4 ^{O}C with supplementary light to provide 16:8 L:D. Refuges consisting of crumpled tissue paper were provided in each cage.

Experimental design: There were three replicates per treatment and seven insects per replicate.

Assessment: The cages were examined daily until all nymphs had moulted and the number of live and dead *L. rugulipennis* recorded.

Analysis of Data: Formal analysis of data was not possible.

Results and Discussion:

Table 8 shows the mortality of *L. rugulipennis* nymphs exposed to buprofezin directly or indirectly compared to untreated controls. There was no evidence to suggest that buprofezin prevented *L. rugulipennis* nymphs moulting.

Table 8. Mortality of *L. rugulipennis* nymphs exposed to buprofezin in two treatments compared to untreated controls.

Treatment	Percentage mortality of nymphs at day: (mean of 3 replicates)			
	1	2	3	4
1. Untreated control	0	4.8	14.3	14.3
2. Sprayed insects	4.8	4.8	4.8	9.5
3. Sprayed plants	4.8	4.8	4.8	4.8

Experiment 2 - Title:

Preliminary study to determine the effect of buprofezin on oviposition by *Lygus rugulipennis*

Materials and Methods:

Site: HRI, Stockbridge House, Controlled temperature room

Insects: Adult female *L. rugulipennis* reared on potato in cultures at HRI Stockbridge House

Plants: Sprouting potato tubers

Treatments:
1. Untreated control – *L. rugulipennis* on untreated cucumber plants.
2. *L. rugulipennis* sprayed with buprofezin in vitro and then placed on untreated potato tubers
3. *L. rugulipennis* placed on potato tubers that had been sprayed with buprofezin

Application: Buprofezin was applied at the rate of 30g product per 100 litre water. In treatment 2, *L. rugulipennis* were temporarily "knocked out" with CO^2, placed on a cucumber leaf and sprayed to maximum leaf retention using a Hozelock sprayer before being transferred to untreated pototoes. In treatment 3, potatoes were sprayed to maximum leaf retention using a Hozelock sprayer before *L. rugulipennis* were transferred on to them.

Environment: Following treatment the insects and potatoes were placed in perspex cages and maintained at 21^{O}C +/- 3 ^{O}C with supplementary light to provide 16:8 L:D. Refuges consisting of crumpled tissue paper were provided in each cage.

Experimental design: There was one replicate per treatment and 13 insects per replicate.

Assessment: The insects were removed from the cages 3.5 days after application of buprofezin. During the following 21 days, the cages were examined regularly and nymphs were removed as recorded as they hatched.

Analysis of Data: Formal analysis of data was not possible.

Results and Discussion:

Table 9 shows the numbers of nymphs produced in each of the three treatments during 21 days following application of buprofezin. The results were variable but there was no indication that either direct or indirect exposure to buprofezin had a major impact on oviposition by *L. rugulipennis.* This will not be further evaluated in replicated experiments.

Table 9. Numbers of nymphs produced by female *L. rugulipennis* in each of the three treatments following exposure to buprofezin.

Treatment	Total number of nymphs produced
1. Untreated control	39
2. Sprayed insects	102
3. Sprayed plants	45

PART 8 – SURVEYS OF POSSIBLE OVERWINTERING SITES FOR *LYGUS RUGULIPENNIS* AND *LIOCORIS TRIPUSTULATUS*

Experiment Title:

To identify the overwintering sites of *Lygus rugulipennis* and *Liocoris tripustulatus*.

Introduction:

The ecology of the capsids *L. rugulipennis* and *L. tripustulatus* is not well known. In particular there is little information about where the adult capsids spend the winter months, prior to invading the glasshouses. Evidence from the literature and discussions with other researchers suggest that the capsids may overwinter in plant litter close to sites where they have been active during warmer parts of the year. A series of sites were surveyed in an attempt to identify the overwintering sites.

Materials and Methods:

Litter samples (30 cm^3 of leaves, grass etc.) were collected and examined for the presence of capsids. In each case the samples were either hand sorted or insects were expelled using a modified Tullgren funnel. Samples were taken:

1. On 18 December 1998 from four locations at Stockbridge House (SE 5536) - two experimental plots from which capsids were taken in the summer, a field boundary, near an area of beech trees next to these fields, and leaf litter and vegetation beneath the beech trees. Ten samples were taken from each location.
2. On 18 February 1999 from three locations at Close House, Heddon-on-the-Wall (NZ 1265) - five samples were taken from each of three mixed woodland sites, all with nettles in an attempt to find *L. tripustulatus*.
3. On 5 March 1999 from three locations at Stockbridge House - five samples were taken from each of three sites with nettles.

Results and Discussion:

Table 10 shows that very few capsids were retrieved from the litter samples. Most samples were negative, with just two *L. rugulipennis* retrieved from beech litter at Stockbridge House. Further studies of potential overwintering sites will be carried out in 1999/2000 in light of the results from 1999 summer field sampling.

Table 10. Summary of overwintering site sampling.

Sampling date	Location	Total no. and species of capsids
18/12/98	HRI Stockbridge House	2 *L. rugulipennis*
18/2/99	Close House, Heddon	0
5/3/99	HRI Stockbridge House	to be completed

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