ORGANIC FARMING RESEARCH FOUNDATION

Project report submitted to the Organic Farming Research Foundation:

Project Title:

Using *Pediobius foveolatus* as a biological control agent for Mexican bean beetle in snap beans

FINAL PROJECT REPORT

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Project Summary

Introduction

Snap beans are in demand at farmer's markets and farmstands. However, snap bean production is difficult for organic growers in Connecticut (most of whom have small farms producing vegetables for local retail sales) because of the Mexican bean beetle. The Mexican bean beetle population builds over the growing season, overwinters locally, and has few significant native natural enemies. Thus, if the farmer tries to grow multiple plantings per year in order to have fresh beans available over the season, local populations build up over time to damaging levels.

Pediobius foveolatus (Crawford) (Hymenoptera: Eulophidae) has been used for biological control of Mexican bean beetles *Epilachna varivestis* Mulsant (Coleoptera: Coccinellidae) in soybeans on a county-wide scale for over 20 years in Maryland and New Jersey. *P. foveolatus* parasitizes 2nd-4th instar Mexican bean beetle larvae (and the same stages of squash beetle larvae, a closely related species). Each mummy produces multiple wasps (ideally ~20 per 4th instar larvae, but varying in the field from 3 -70). Because *P. foveolatus* does not overwinter, it has to be re-released each year. Also, because these wasps are too expensive (minimum of $25 per thousand plus shipping in 2000) to use in inundative releases, existing programs use a strategy of inoculative release and depend on multiplication in the field over the growing season.

The protocol used in New Jersey and Maryland, where state governments maintain *P. foveolatus* colonies for the large-scale soybean growers, is well established: The soybean grower plants a small, early planting of snap beans to attract a Mexican bean beetle population, and releases the *P. foveolatus* wasps into that population. Then, when soybeans are planted later, a local *P. foveolatus* population is already on hand to control Mexican bean beetles in this less attractive crop.

However, the situation in snap beans is different because of the greater susceptibility of snap beans to Mexican bean beetles, the multiple plantings per year, and the small plots of beans grown by organic growers in Connecticut. It is also different because the summer is shorter and cooler in Connecticut, which limits the annual reproduction of the *Pediobius.*

This grant from OFRF funded the third year of research on biological control of Mexican bean beetle with *Pediobius.* I am presenting some data from all 3 years because the larger data pool will give the reader a better idea of the general results, and because some of the questions addressed in the research funded by this grant involved possible carry-over effects from one year to another in reduced Mexican bean beetle populations.

Objectives

1) Test two options for reducing damage from Mexican bean beetle in the first year of release: a) Raise the release rate of wasps, and b) Apply one spray of a botanical insecticide to reduce the initial density of adult beetles, then release the wasps at the usual rate after the spray residue is gone and when remaining beetles are in the appropriate larval stage.

2) Accurately measure the initial density of adult Mexican bean beetles at first , second, and third year release sites and control sites, and follow the population through the season, with an emphasis on measuring the effect of *Pediobius* on production of pupae and adults in the first and second beetle generations.

Materials and Methods

Sites

All sites are highly diversified vegetable farms with 50 to 1000 m^2 of beans at the time of the first release. All had multiple plantings of beans in order to be able to pick from July - early October.

1998: Releases at 3 organic farms and 1 experimental farm. Control sites were 2 organic farms
1999: Releases at 6 organic farms and 1 experimental farm. Control sites were 3 organic farms.
2000: Releases at 12 organic farms (except where unnecessary). Experimental farm was control site.

Protocol for Releases

1998: We purchased mummies from the New Jersey Department of Agriculture. Releases were made by tying a fiberglass screen packet of mummies to a bean plant. The first release was made within 3 days when we saw eggs in the field, the second release was one week later. A third release was sometimes made later at the request of the farmer. Assuming 20 wasps per mummy, we used 30 to 60 wasps per m^2 of beans per release.

1999: Wasps were donated by the Maryland Department of Agriculture, and had emerged from the mummies inside cups at the time of release. Releases were made by opening the cup in the bean field. The first release was made within 3 days when 1st instar larvae were found in the field, the second release was made within a week, and a third release was made at some farms at the request of the farmer. In first year sites, which generally had higher initial bean beetle densities, we used 30-60 wasps per m^2 of beans per release. In second year sites, we used 2-3 per m^2 of beans per release.

2000: Wasps again were donated by the Maryland Department of Agriculture, and releases were made as in 1999. In some first year sites with high initial adult populations, we sprayed once with rotenone before the first release (as shown for Granby). In first year sites, we used 60-80 wasps per m^2 of beans per release. In second and third year sites, we used 2-8 per m^2 of beans per release.

Sampling

The sample unit was a frame 0.5 m^2 in area. Until the first release, 20 samples per site were taken weekly. After the first release 10 samples per site were taken. Adults, intact egg masses, hatching egg masses (before dispersal of the larvae), small larvae (1st-2nd instars), large larvae (3rd-4th instars), pupae, and mummies were counted on the plants. After the first release, large larvae found in the samples (up to 100 per week per site) were brought back to the laboratory for rearing to determine the percentage parasitized.

Project Results

Field Results

Continuing Study in 2000 of farms where *P. foveolatus* had already been released for 2 years:

For those farms where we started doing releases in 1998, continued in 1999, with 2000 the third year of release, the control of Mexican bean beetles in 2000 was not generally quite as good as that in 1999, but still much better than in 1998. (See graphs on p. 1 and p. 2 of the accompanying Powerpoint files for Cromwell, Easton, and Shelton.)

In 1998, all three of these farms had densities of large (3^{rd} –4^{th} instar) Mexican bean beetle larvae from 20 to 45 per m^2 on either July 21 or July 28. These were very damaging populations, and decreases in numbers at Cromwell and Easton were more likely due to such heavy defoliation that the Mexican bean beetles ran out of food than due to the rather small rates of parasitism from *P. foveolatus* in that first year, despite the high initial release rates. At Cromwell in 1998, as in several previous years, no snap beans were harvested after Labor Day, despite several more weeks of frost-free weather, because of damage from the beetles and their larvae. At Lockwood Farm in Hamden (the Experiment Station farm, also on p. 2), the peak density of large beetle larvae was lower and later (14.5 per m^2 on August 13) and the peak production of mummies was much higher (16 per m^2) than at the other farms, perhaps because we were studying several widely separated plots, unlike at the commercial farms where successive bean plantings were close together. (Mexican bean beetle larvae can walk only a few yards between successive plantings, and the beetle adults do limited flying in mid-season, but the wasps are very highly mobile throughout the summer.)

In 1999, for these four farms (Cromwell, Easton, Shelton, and Hamden), the numbers of Mexican bean beetles and their timing in the field was dramatically different than in 1998, even before the new releases were made. Because it is well-established that *P. foveolatus* does not overwinter, this reduction in numbers and delay in appearance in the field would either be due to reduced local populations at each of the farms (perhaps as a result of biological control in the previous year and thus reduced numbers of Mexican bean beetle adults going into overwintering) or reduced numbers or delayed emergence from overwintering on a regional basis. These four farms are separated by a maximum distance of about 50 miles. Because of the delayed appearance and reduced number of Mexican bean beetles in 1999, the wasps were released much later in the season and in much lower densities than in 1998.

In 2000, as mentioned above, all of these farms had more large larvae than in 1999, but they were fewer and later in the season than in 2000.

Farms with comparisons of no release (control) to one year of release:

In order to better determine whether release of *P. foveolatus* had any effect on Mexican bean beetle numbers in the first year of release, we studied several sites two years in succession, with no release in the first year studied (control site) and with a release of *P. foveolatus* according to the above protocol for first year releases in the second year of the study. The graphs for these four farms are shown on p. 3 of the Powerpoint file. There is no evidence of reduced numbers of large larvae or adults late in the season in any of the farms with releases, compared to the previous year when no wasps were released.

Farms with one year of release and those sprayed once before release:

There were four additional farms studied only one year, the year of first release (either 1999 or 2000). Again, these farms varied considerably in initial population densities of Mexican bean beetles, but there was no indication of effective control in the first year for those populations that were damaging.

We had planned to test an early season application of rotenone as a way of bringing down the initial influx as adults, before releasing *P. foveolatus* at least one week later. (This was in 2000, when formulations of rotenone acceptable to the local organic certifier were available.) We found that the organic farms we worked with in Connecticut were very reluctant to spray rotenone on a food crop, even early in the season, long before any beans would be present. The only two farmers who did were in Oneco in 2000 (bottom of p. 3) with the spray timed for control of potato leafhopper, and Granby in 2000 (top of p. 4), which had by far the greatest Mexican bean beetle density of any farm studied.

Costs of using *P. foveolatus* for biological control:

Because the Experiment Station paid for the wasps in 1998 and for the shipping costs for the wasps and for my time in all 3 years, the Maryland Department of Agriculture donated the wasps in 1999 and 2000, and OFRF paid for summer assistance in 2000, there was no cost to the growers for this biological control program.

If the growers had to buy wasps and released them at the rates we used, this method of control would be expensive. We did not see any benefit in going from 30 – 60 wasps/ m^2 in 1998 and 1999 to 60 – 80 wasps/ m^2 in 2000 (Neither provided control of Mexican bean beetles in the first year. It is possible that the benefit of reduced populations in the second year might be achieved with lower than 30 wasps/ m^2 in the first year, but that possibility has not been studied in our region.) The wasps in 2000 cost $25 per 1000 wasps if purchased from the Maryland Department of Agriculture with an additional shipping cost of about $20 per shipment. Thus the cost for an acre of snap beans at 30 wasps/ m^2 per shipment, and two shipments would be $7010. And this would be for a control that could not be relied upon to show a benefit in the first year.

If the grower used a rate of 3 wasps/ m^2 for each shipment in subsequent years, the cost for an acre of snap beans with two shipments would be $646. While this is still expensive, it is not out of the question for a grower with a high value crop (generally, in Connecticut, sold in direct markets) without any other reliable alternative for control except row covers.

Continued use of biological control after 2000

Only one farmer (Kathy Caruso of Upper Forty Organic Farm in Cromwell) has continued using biological control for Mexican bean beetle, to my knowledge. Many other factors are involved other than the actual biological control program: Two stopped farming altogether, one moved to a different site where Mexican bean beetles are not a problem, two decided to stop growing snap beans because of the labor required to pick them. And for those sites where we did releases in only one year, the farmers never had a chance to see what benefits they might have over a longer period.

For the one farmer who continued, the results have been very successful, however. She had not been able to harvest any snap beans after Labor Day for several years before this project began because of Mexican bean beetle damage to the beans and the leaves. She already saw a major benefit by the second year of releases. In addition to Mexican bean beetle, she also had the closely related squash beetle (*Epilachna borealis*) in her squash, and saw an additional benefit in controlling this species.

We have additional economic information for Upper Forty Organic Farm in Cromwell because this farm was a participant in the NorthEast Organic Network (NEON) project. In 2002, Kathy Caruso continued with biological control on her own (for the third year of release), releasing 2000 wasps in her 0.12 acre field of snap beans at a cost of $80.40. She attributed 75% of this cost to the beans (with the rest going to the squash for control of squash beetle.) This cost, which works out to $519 per acre, was 9% of the total production cost of the snap beans (the majority of which was labor for hand-weeding and hand-picking the beans). Total costs (production costs + overhead + marketing) were $15,219 per acre for snap beans in 2002, but because of her excellent direct marketing of very high quality snap beans, Kathy Caruso still made a substantial profit. This puts into perspective the cost of biological control in Connecticut, where for small organic farms doing direct marketing, both the total costs and total revenues are high, and thus the cost of the biological control (after the first year) is not a major item.

Kathy Caruso would continue with biological control, and scouts her fields each year to determine the need, but was unable to find <u>any</u> Mexican bean beetle adults or larvae in her fields in 2003 or 2004.

Conclusions and Discussion

We were unable to reliably control Mexican bean beetle larvae in first-year release sites, even when spraying rotenone to reduce the adult population and releasing the wasps at rates that would be uneconomical for a farmer.

However, in succeeding years, control could generally be achieved at a release rates that represent an acceptable cost to several of the organic growers (given the premium paid for their crop at their retail stands and the lack of other effective alternatives).

Since the wasp does not overwinter, the carry-over effect from one year to another must involve a lower initial density or later appearance of overwintered Mexican bean beetle adults in the field in the following year. To prove this would require more intensive early season sampling in more sites than we were able to do. Since the major benefit from the first year of releases is this carry-over effect to the next year, more research to clarify how this works would be useful.

At one highly successful farm using *P. foveolatus* for three years, the Mexican bean beetle population disappeared, so further biological control became unnecessary.

Questions for the Future

1. What is the effect of introduction of *P. foveolatus* on a small organic farm on the overwintering population of Mexican bean beetles in the area? How does the "carry-over" effect we consistently see work?
2. How high a release rate of *P. foveolatus* is needed in the first year to get the "carry-over" effect? Could we substantially reduce the initial cost of the program?
3. How does the area of organic beans in a region affect the "carry-over" effect? We have had carry over in Cromwell, where the area of organic beans is quite small compared to neighboring growers of conventional snap beans. What is happening on the neighboring farms?

Outreach

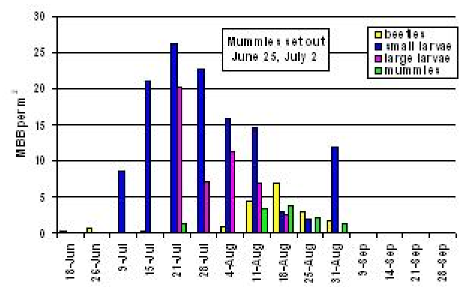
Information collected in this project has been shared with the Maryland and New Jersey Departments of Agriculture, for use in their continuing biological control projects. A poster presenting part of these data was presented at the Joint Meeting of the Entomological Society of America and the Canadian Entomological Society in Montreal in December of 2000; at the Scientific Congress for Organic Agricultural Research and at the Eco-Farms Conference both of which were in Pacific Grove, California in January 2001. Also data from this project were incorporated into Powerpoint presentations on organic methods for pest management presented at the CT NOFA Organic Transition Conference in January 2001, at the Connecticut Farm Fresh Conference in February 2001, and at the Certified Organic Associated Growers meeting in March of 2001.

Appendices: Graphs are attached as a separate series of Powerpoint files.

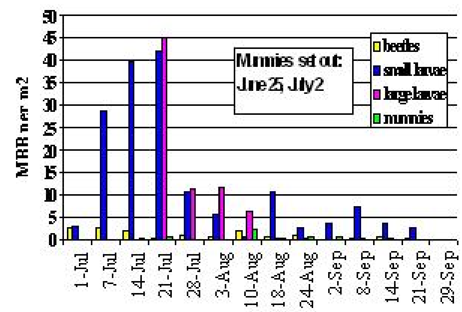
Using *Pediobius foveolatus* as a Biological Control Agent for Mexican Bean Beetle in Snap Beans

Three-year studies: Cromwell and Easton

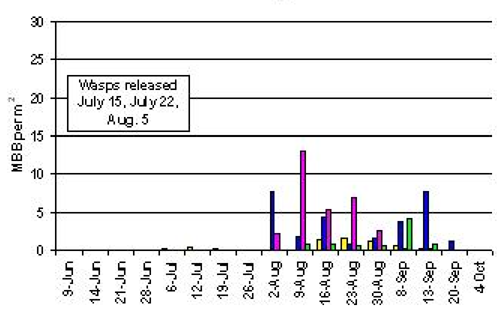
Cromwell 1998: 1st year of release



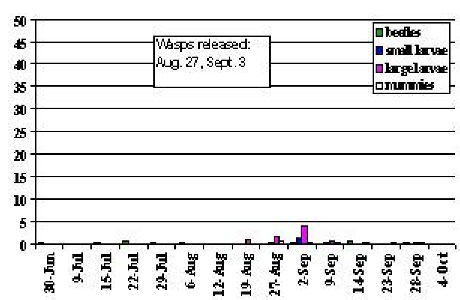
Easton 1998 -1st year of release



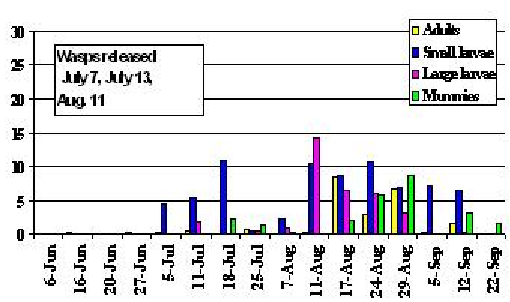
Cromwell 1999: 2nd year of release



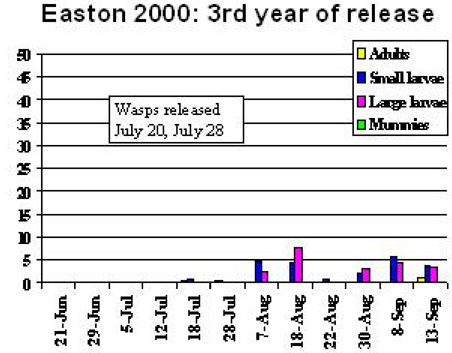
Easton 1999 -2nd year of release



Cromwell 2000 –3rd year of release

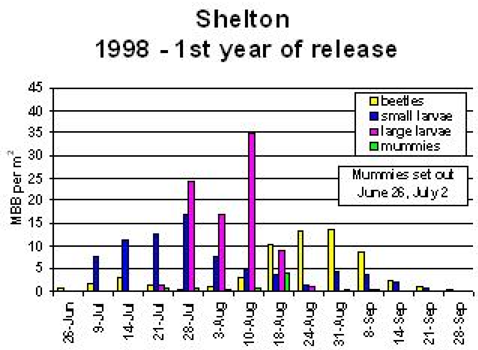


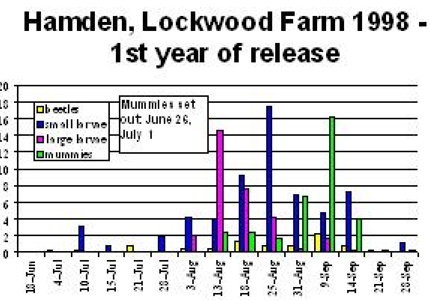
Easton 2000: 3rd year of release

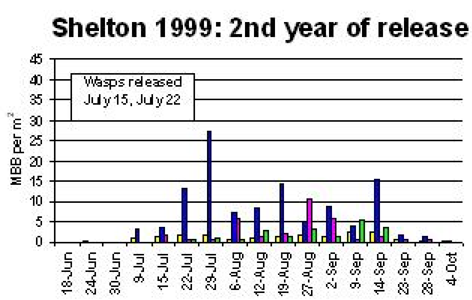


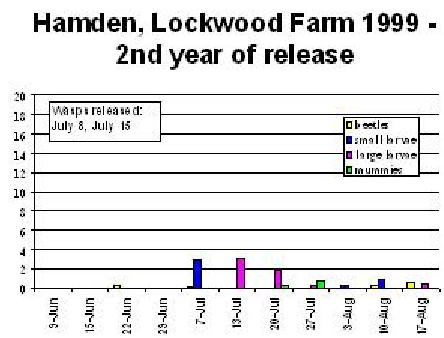
Using *Pediobius foveolatus* as a Biological Control Agent for Mexican Bean Beetle in Snap Beans

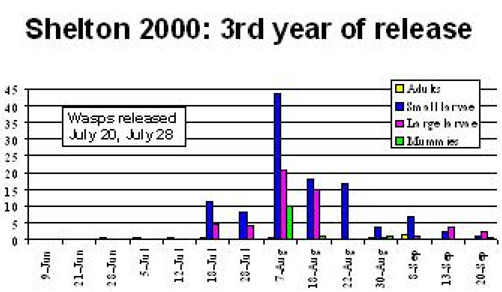
Three-year studies: Shelton and Hamden

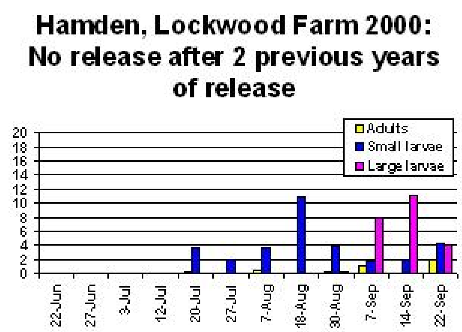








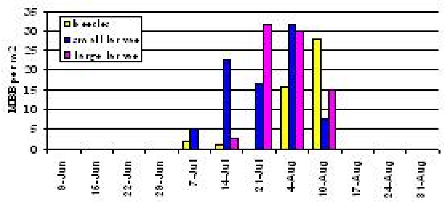




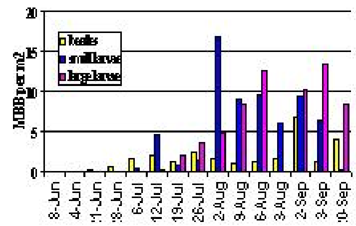
Using *Pediobius foveolatus* as a Biological Control Agent for Mexican Bean Beetle in Snap Beans

2-year studies, No release the first year

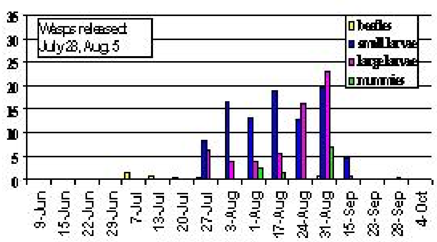
Northford 1998 - Control site, No release



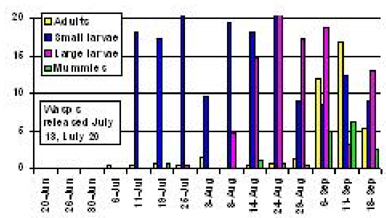
Harwinton 1999 - Control site, No release



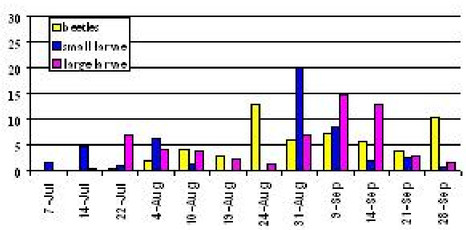
Northford 1999 -1st year of release



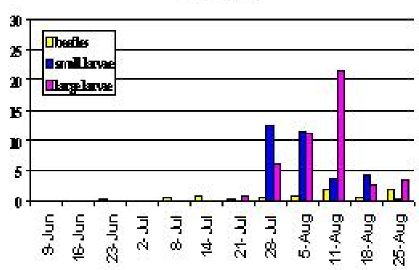
Harwinton 2000: 1st year of release



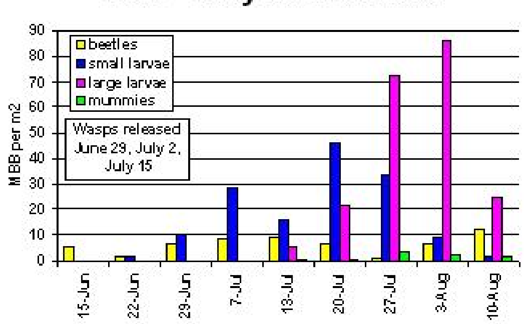
Guilford 1998 Control site, No release



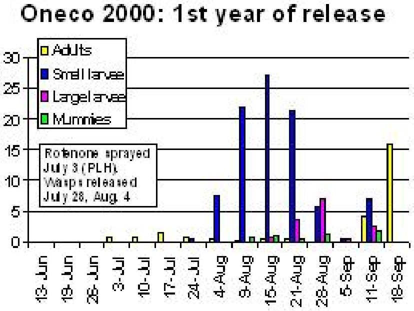
Oneco 1999 - Control site, No release



Guilford 1999 - 1st year of release



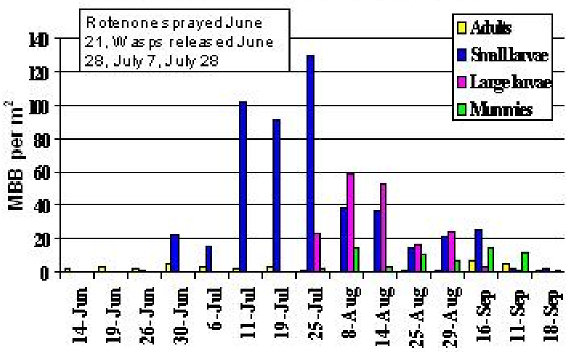
Oneco 2000: 1st year of release



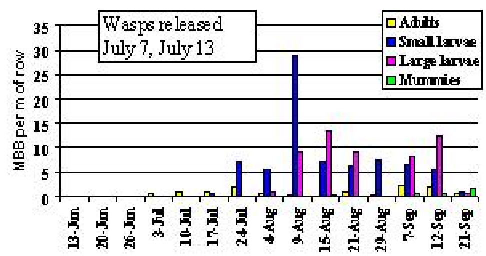
Using *Pediobius foveolatus* as a Biological Control Agent for Mexican Bean Beetle in Snap Beans

1st year releases – Studied only one year

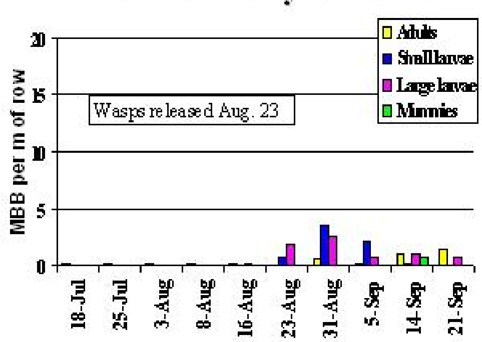
Granby 2000: 1st year of release



Salem 2000: 1st year of release



New Britain 2000: 1st year of release



Glastonbury 1999 - 1st year of release