Biological Control of the Mexican Bean Beetle *Epilachna varivestis* (Coleoptera: Coccinellidae) Using the Parasitic Wasp *Pediobius foveolatus* (Hymenoptera: Eulophidae)

2006

Mexican bean beetle larvae

P. foveolatus on larva

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SCOPE AND COVERAGE

In 2006, the Mexican bean beetle (MBB) *Epilachna varivestis* (Coleoptera: Coccinellidae) biological control program involved 30 growers with 55 nurse plots. This was a decrease of 9 plots from 2005. Planting began on May 2 with the last plot planted on May 22, well before the Memorial Day target date. This insures that the snap beans germinate in sufficient time to attract the overwintering MBB adults. All nurse plots were treated at planting with the preemergence herbicides Pursuit and Dual at Rutgers recommended rates.

MATERIALS AND METHODS: Nurse Plots and Releases

One-eighth acre nurse plots were planted in areas adjacent to soybean fields with a mixture of 15 lbs. of snap beans and 5 lbs. of soybeans before the grower's plant (Figure 1). The snap beans germinate first and attract any overwintering MBB adults in the area to the nurse plot (Figure 2). The only available food source for the MBB at that time is the snap beans with the beetles preferring to feed on snap beans versus soybeans. Once the snap beans are consumed, the later germinating soybeans keep the beetles in the plot and out of the farmer's field. The New Jersey Department of Agriculture, Phillip Alampi Beneficial Insect Laboratory (PABIL) uses the nurse plot system as a "trap crop" to lure in the MBB (Figure 3) and keep them in the plot. The parasitoid *Pediobius foveolatus* (Hymenoptera: Eulophidae) is released into the plot and the early releases allow for rapid buildup of parasites within the nurse plots. Although *P. foveolatus* females prefer third and fourth instar larvae, they attack all instars or larval stages of the Mexican bean beetle and oviposit an average of 25 eggs within each larva. The parasitized larvae eventually die, forming dark brown "mummies" (Figure 4). *P. foveolatus* is a gregarious parasite with an average of 25 wasps, of which approximately 75% are female, emerging from each mummy. The emerging wasps attack all larval stages in the nurse plot and continue to search for and parasitize any healthy MBB larvae, which may have dispersed from the nurse plot into the farmer's adjacent soybean field.

Figure 1. Planting nurse plot

Figure 2. Nurse plot

P. foveolatus releases are based on initial egg sighting (**egg release**) and larval counts (**trigger release**). Since 1985 egg releases have consisted of a total of 6,000 parasites with the first release of 3,000 *P. foveolatus* made at the first observation of a Mexican bean beetle (MBB) egg cluster. The second egg release of 3,000 parasites is made two to three days later; trigger releases began when larvae were first observed. The initial trigger release was divided into two releases, two to three days apart. If the MBB larval count increased seven days after the initial trigger release, then a second single trigger release was made. Table 1 shows the decision table developed by the NJDA.

Release decisions were based on monitoring the nurse plots two times per week; the sampling unit within each plot consisted of 125 plants with 25 plants examined in each of five locations where MBB feeding is observed.

Beginning in 2000, some releases of *P. foveolatus* were released in the form of parasitized Mexican bean beetle larvae or "mummies" versus adults. For example, if 2,000 parasites were required for a nurse plot, an equivalent of 80 mummies were released in 3"x 6" x 1.75" paper bags with holes large enough for *P. foveolatus* to emerge, twist tied to the bean plant (Figure 5). There is an average of 25 parasites developing per mummy so the equivalent number of parasites was released. This change in procedure allowed the PABIL to increase efficiency and to release the requisite number of parasites using fewer laboratory man-hours. No loss of efficacy was noted in the field. The paper bags are left in the field and do not have to be collected and returned to the laboratory.

In 2006 release procedures were further modified due to a 50% cut in summer staff. Egg releases consisted of one release of 4,000 parasites in the form of "mummies" instead, of 2 releases of 3,000. Trigger release methodology remained the same but the number of surveys was reduced from twice a weekly to weekly after the egg releases had taken place. This reduced the amount of time field staff was in the plots.

Figure 3. Mexican bean beetle adult

Figure 4. Parasitized larva (mummy)

Figure 5. Release bag in beans and mummies

All bags/containers are kept cool in insulated Styrofoam containers (bio-mailers) with blue ice until the parasites are ready to be released.

Direct field releases are made into other fields using surplus adult parasites that were not needed in the nurse plots.

RESULTS AND DISCUSSION

Mexican Bean Beetle Levels, Parasites Released And Parasitism

The peak percent parasitism in the nurse plots averaged 11.0% (Table 2). In nurse plots where releases were made, only 21.8% of the nurse plots required egg releases as compared to 20.3% of the plots last year. Trigger releases were required in 38.2% of the plots versus 42.2% of the plots in 2005. A total of 174,000 parasites were released into the nurse plots with an average of 3,010 per plot. MBB populations developed in 60% of the nurse plots compared to 62.5 %, 64.5%, 38.1%, 77%, and 76.4%, for the five preceding years (Tables 2 and 3). Releases were made in 33 of the 55 nurse plots (Table 2).

Historically, from the time the program was implemented in 1980, until 1991, Cumberland County had the greatest MBB pressure; however in 1991 Salem County developed the highest populations and continued to have the highest populations until 1997. From 1998 to 2004 Monmouth County had the highest MBB populations while in 2005, Burlington County had the highest populations. In 2006, Cumberland County had the highest levels of Mexican bean beetle in 2006 and there was one hot spot near Port Norris where adult Mexican bean beetle got into the grower's field. The population there did not cause economic damage, however.

In 2006 there was a slight decrease in activity in all of the counties, as compared to 2005. The MBB population continues to remain at low levels overall when one looks at the number of *Pediobius foveolatus* released (Table 2). The data indicate that the populations of MBB remain at a lowered carrying capacity due to the release of *P. foveolatus.* Essentially this means that the maximum MBB population that the environment will support is reduced from what it would be if the *P. foveolatus* were not released.

The percentage of plots requiring releases in 2006 slightly decreased statewide.

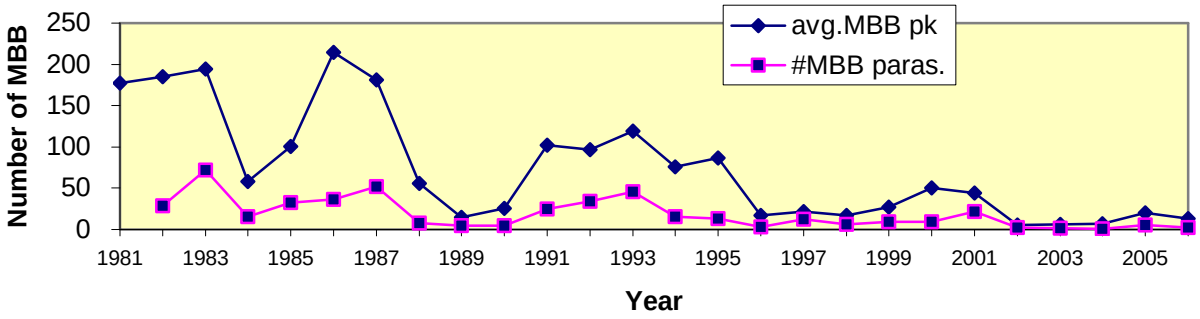
No participating grower had to spray for Mexican bean beetle control nor was there any need for preventive applications to any of the nurse plots.

E. varivestis Population Levels

Figure 5 shows the "host peak" (a measure of the Mexican Bean Beetle population in the nurse plots) and the number of hosts parasitized in the nurse plots over time. The number of parasites released in the nurse plots follows the *E. varivestis* population fluctuations where more *P. foveolatus* are released in years of greater bean beetle pressure and less in years with reduced populations. There have been fluctuations in *E. varivestis* numbers since 1981 and the number of *P. foveolatus* released has followed this cycle. Insect populations are cyclical and the MBB population shown in Figure 5 is no exception. The key observation about Figure 5 is that the peak population of the MBB in the 90's is half of what it was in the 80's and the present populations are one fourth of what they were in the 1980's. This trend has continued and the MBB population is currently held at a maintenance level as a direct result of the NJDA's MBB program.

The anecdotal evidence from observations by the field staff supports the idea that the overwintering populations are reduced in areas where nurse plots are present but MBB population hot spots still occur. The hot spots are located in areas where nurse plots have not been planted for a few seasons or if there is migration from other states. The evidence is that all counties but Salem have not had seriously high MBB populations since the mid-1980's. Salem's increase was possibly due to flights of MBB from neighboring states and the fact that some growers retired from farming and left the program. The nurse plots on their property were not replaced until some years later. The increase in MBB populations in 1990 to 1993 in Figure 5 is almost all due to Salem County. Monmouth County's numbers are higher over the past several years but are not due to migrations from other states as they were for the increases in Salem. Figure 5 also shows that the MBB population levels are not as high since 2000 as they were in the 1990's or 1980's. This is evidence that the releases by the PABIL have decreased the MBB population in the state. The peak populations are no longer as high as the past. Dively (1985) stated that the MBB population levels are more dependent on weather and the biology of the insect rather than *P. foveolatus* and that the MBB possesses great potential to bounce back within three years as was seen in the Battlefield area of Monmouth County where a "hot-spot" developed. The release of *P. foveolatus* has kept the MBB population below economic levels and as long as the MBB program is continued, growers in New Jersey should not experience serious problems with the MBB.

Figure 5. Mexican bean beetle Population and Parasitism 1981-2006



Parasitism data is dependent on the scouts finding mummies; if mummies are on bean leaves that have abscised and fallen to the ground, the mummies are more difficult to find. Therefore, parasitism data is underrepresented and the parasitism is probably greater than what is shown in Figure 5 and in Tables 2 and 3.

Direct Field Releases

In 2006, as in past years, field releases of surplus parasites were made to keep additional pressure on the MBB population (Table 4). Direct field releases are made in mid to late season wherever MBB are observed and consist of parasites that have not been used in the nurse plot program. Field releases are made directly into soybean, snap bean and lima bean fields throughout Central and Southern New Jersey. In 2006, there were 24 direct field releases totaling 252,000 parasites. The bulk of the releases were made in Salem County where 114,000 parasites were released, followed by Cumberland with 76,000. Including the number of parasites released in the nurse plots, a total of 426,000 parasites were released statewide. The number of parasites released in direct field releases depends on the number of *P. foveolatus* available and is not linked to a decision table. The purpose of the field releases is threefold: 1) to suppress the MBB in areas where it could attain high population levels and 2) to reduce the over wintering population of MBB 3) to reduce the *P. foveolatus* storage stocks in the laboratory. There is no correlation between the MBB population and the number of surplus parasites released.

Using *P. foveolatus* has resulted in substantial savings to the growers in reduced insecticide costs since 1981.

SUMMARY AND CONCLUSION

Overall this was a successful year MBB the populations have continued to decrease in all counties. Parasitism levels have increased, this season; there is no evidence of MBB populations returning to the levels observed in the past.

A portion of the soybean check-off funds reserved for research has been allocated to the NJDA and is used to offset some of the costs for field implementation of the biological control program. In New Jersey, populations of bean beetles are kept below economically damaging levels in areas where there are nurse plots but also protect other soybean and bean fields in the area due to parasite dispersal. Additionally, there is no economic impact on the growers from the more damaging second-generation MBB population. Even though a grower may not have any nurse plots adjacent to his fields, that grower still benefits because the plots are carefully positioned so that the majority of the bean producing areas in the state are protected by the parasites.

E. varivestis has the potential to “bounce back” and become a problem again, however it can be kept from economically damaging levels as long as the Phillip Alampi Beneficial Insect Laboratory can maintain its highly effective nurse plot monitoring and parasite release program.

2007 PLANS

Plans for the upcoming season are to keep parasite pressure on developing MBB populations by maintaining maintenance numbers of Nurse Plots throughout the counties with Mexican bean beetle populations. The number of plots statewide will remain between 55-60 due to the overall decline in the MBB population. If the MBB populations increase in the future, the

number of plots will be increased in those areas of higher MBB levels. The Port Norris area of Cumberland County is one such area. Mummy releases worked well and will continue in 2007.

TABLE 1. *Pediobius foveolatus* DECISION TABLE DEVELOPED BY NJDA

Pediobius foveolatus Parasite Release Decision Table

Peak Larval Count[1]	Total *Pediobius* Release (Adults)	First Trigger		Second Trigger	
		#Adults	#Screens/bags	#Adults	#Screens/bags
1-150	2,000	2000	2		
151-225	4,000	2000	2	2000	2
226-300	10,000	6000	6	4000	4
301-375	14,000	8000	8	6000	6
376-450	18,000	10000	10	8000	8
451-525	22,000	12000	12	10000	10
526+	26,000	14000	14	12000	12

[1]Total number of all larvae (1^{st} – 4^{th} instars) in 125-plant nurse plot sample.

(40 mummies; approx. 1,000 *P. foveolatus* adults) per paper bag.

TABLE 2. NURSE PLOT SUMMARY BY COUNTY 2006

County	Total No. of Plots	Total No. of Parasites Released	Average No. of *P. foveolatus* Released per Plot	No. of Plots with *P. foveolatus* Releases	Percent of Plots with *P. foveolatus* Releases	Average Percent Parasitism	No. of Plots with Egg Releases Only	No. of Plots with Trigger Releases
BURLINGTON	4	10,000	2500	2	50.0	5.7	0	2
CUMBERLAND	17	68,000	4000	11	64.7	11.4	3	8
GLOUCESTER	7	20,000	2857	5	71.4	10.9	3	2
MERCER	2	6,000	3000	1	50.0	5	0	1
MONMOUTH	8	24,000	3000	4	50.0	12.6	1	3
SALEM	17	46,000	2705	10	58.8	8.9	5	5
TOTAL	55	174,000		33	57.5		12	21
AVG. LEVELS			3010			11		

TABLE 3. NURSE PLOT SUMMARY BY YEAR

Year	Total No. of Plots	Total No. of Parasites Released	Average No. of *P. foveolatus* Released per Plot	No. of Plots with *P. foveolatus* Releases	Percent of Plots with *P. foveolatus* Releases	Average Percent Parasitism	No. of Plots with Egg Releases Only	No. of Plots with Trigger Releases
2006	55	174,000	3010	33	57.5	11	12	21
2005	64	275,000	4588	40	62.5	3.8	13	27
2004	62	252,000	3475	40	64.5	11.4	23	16
2003	84	216,000	2156	32	38.1	10.2	20	12
2002	96	544,000	5975	74	77	20.6	39	35
2001	89	578,000	7009	68	76.4	49.4	21	47
2000	90	520,000	5778	64	69	26.4	16	47
1999	96	710,000	7395	80	83.3	25.1	34	46
1998	108	680,000	6296	79	73.1	22.9	19	60
1997	113	834,000	7381	98	86.7	41.7	29	69
1996	109	670,000	6204	79	72	11.2	24	49
1995	120	828,000	6900	86	71.6	35.2	17	57
1994	120	850,000	7083	72	60	17.2	22	27
1993	111	1,101,600	9924	99	89.2	28.9	26	41
1992	112	1,272,000	11357	106	95	36.9	39	25
1991	100	1,000,000	10000	84	84	22.8	23	31
1990	106	628,000	5925	70	66	17.7	16	9
1989	130	424,000	3240	63	48.1	33.8	54	8
1988	118	682,000	8883	76	64.4	14.2	62	10
1987	117	1,260,000	10125	110	94.0	28.7	39	64
1986	117	1,541,000	9487	108	92.3	17.1	49	32
1985	111	1,156,500	9973			32.3		
1984	108	633,000	6806			27.1		
1983	139	975,000	8705			37.1		

TABLE 4. SUMMARY OF ALL RELEASES IN 2006

	FIELD RELEASES		NURSE PLOT RELEASES		
County	**#Field Releases**	***#P. foveolatus* Released**	**Number of Nurse Plots**	***#P. foveolatus* Released in Nurse Plots**	**Total *#P. foveolatus* Released**
Atlantic	1	10,000			10,000
Burlington			4	10,000	10,000
Cape May	10	114,000			114,000
Cumberland	7	76,000	17	68,000	144,000
Gloucester			7	20,000	20,000
Mercer			2	6,000	6,000
Monmouth			8	24,000	24,000
Morris	1	4,000			4,000
Salem	5	48,000	17	46,000	94,000
TOTAL	24	252,000	55	174,000	426,000

Total Parasites Released Statewide including nurse plots= 426,000

REFERENCES

1985. Dively, G.P. Mexican Bean Beetle Biological control Demonstration Project: 1980-1983. Conducted By The State Departments of Agriculture in Delaware, Maryland,
New Jersey, and Virginia in Cooperation with the USDA-APHIS-PPQ National Biological Control Program.