Parasitization of the Mexican Bean Beetle[1] by *Pediobius foveolatus*[2] in Urban Vegetable Gardens[3]

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ABSTRACT

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Parasitization of the Mexican bean beetle (MBB), *Epilachna varivestis*, by the wasp *Pediobius foveolatus* was monitored in five urban vegetable gardens in Washington, D.C., in 1979 and 1980. We innoculated all five gardens with *P. foveolatus* in 1979 and one of these gardens in 1980. This wasp is an exotic, non–overwintering biocontrol agent that is used in Maryland soybean fields. Our innoculative releases, *P. foveolatus* that probably came from Maryland, or both parasitized from 97 to 100% of the MBB larvae in each garden by late summer. Therefore, most of the MBB damage in these urban gardens probably could be eliminated by making innoculative releases of adequate numbers of *P. foveolatus* throughout gardens at appropriate times.

The Mexican bean beetle (MBB), *Epilachna varivestis* Mulsant, is an important pest of beans and soybeans throughout continental United States. It can be controlled by the exotic chalcidoid wasp *Pediobius foveolatus* (Crawford), but unfortunately it appears unable to overwinter in temporate regions and must be released each year for biological control purposes. Stevens et al. (1975) used annual innoculative releases of *P. foveolatus* to suppress MBBs in Maryland soybean fields, and this biocontrol program has continued to the present. Yet, despite the successful use of *P. foveolatus* in soybean fields, it has not been previously used in other situations, e.g., vegetable gardens.

In community vegetable gardens in Washington, D.C., MBBs totally defoliate bean plants by midsummer if control measures are not taken. Gardeners commonly apply chemical pesticides to control these pests, increasing pesticide pollution in this urban area. The pesticide load in Washington, D.C., has not been quantified but may be larger than in surrounding agricultural areas, as is the case in other cities (von Rümker et al. 1972). Regardless of pesticide use in Washington gardens, *P. foveolatus* were frequently found parasitizing MBBs in the autumn of 1977 and 1978, but this was after MBBs had significantly damaged beans. No one is known to have released this wasp in this city before 1979; thus, it probably entered the city from Maryland soybean fields. It has been reported to move about 160 km in one season, most likely being carried by wind (Coulson 1976).

In an attempt to assess the ability of *P. foveolatus* to control MBBs and further biological knowledge of insects in urban vegetable gardens in general, we released and monitored this wasp in 1979 and 1980 in Washington, D.C. Notwithstanding the prevalence of urban "vegetable patches" in the United States, there are almost no studies that deal primarily with their beneficial and pestiferous arthropods (Frankie and Koehler 1978). Such studies could help to reduce the use of unnecessary, polluting pesticides in urban areas.

Materials and Methods

MBBs and *P. foveolatus* were obtained from the Maryland Department of Agriculture, College Park. The beetles were reared on bush beans, *Phaseolus vulgaris* L., in 38-liter, glass terraria and were used as hosts for the wasp. The terraria were maintained under natural and fluorescent lighting and contained jars of leafy bean stems or pots of rooted bean plants on which MBBs fed. Fresh foliage was provided whenever the MBBs were short of food. To rear *P. foveolatus*, mated females were placed in petri dishes with 4th-instar MBB larvae; wasps usually parasitized all of the larvae within 24 h. The parasitized larvae were maintained in petri dishes until wasps emerged and mated. Then the wasps were used to maintain their culture or release in gardens.

Fifty mated, 2- to 6-day-old female *P. foveolatus* were released between 1500 and 2000 h in the second week of July in 1979 and 1980 in bean patches infested with MBB larvae. Wasps were released in the Glover Park and Chesapeake, Newark, Sedgwick, and W Street gardens in 1979 and in the Glover Park garden in 1980. The gardens were from 492 to 9,338 m^2 (4,140.8 ± 1,558.56), contained from 12 to 120 garden plots (60.8 ± 17.79),and were immediately surrounded by grassy park areas or forests (Fig. 1). Buildings, national forests, and other parts of the city separated the gardens. Four of the gardens were from 1.1 to 1.9 km (1.52 ± 0.176) from the centrally located Newark Street garden. No effort was made to upset gardeners by asking them to change any of their gardening practices, e.g., not applying pesticides or planting nectar plants for chalcidoid wasps.

Week 0 designates the week of wasp release; week 1, the first week after release, etc. Collecting was initiated in a random area of each bean patch and the first older MBB larvae that were encountered were collected to reduce sampling bias. The MBBs were maintained in 0.5-liter paper cartons or plastic

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[2] Hymenoptera: Eulophidae.
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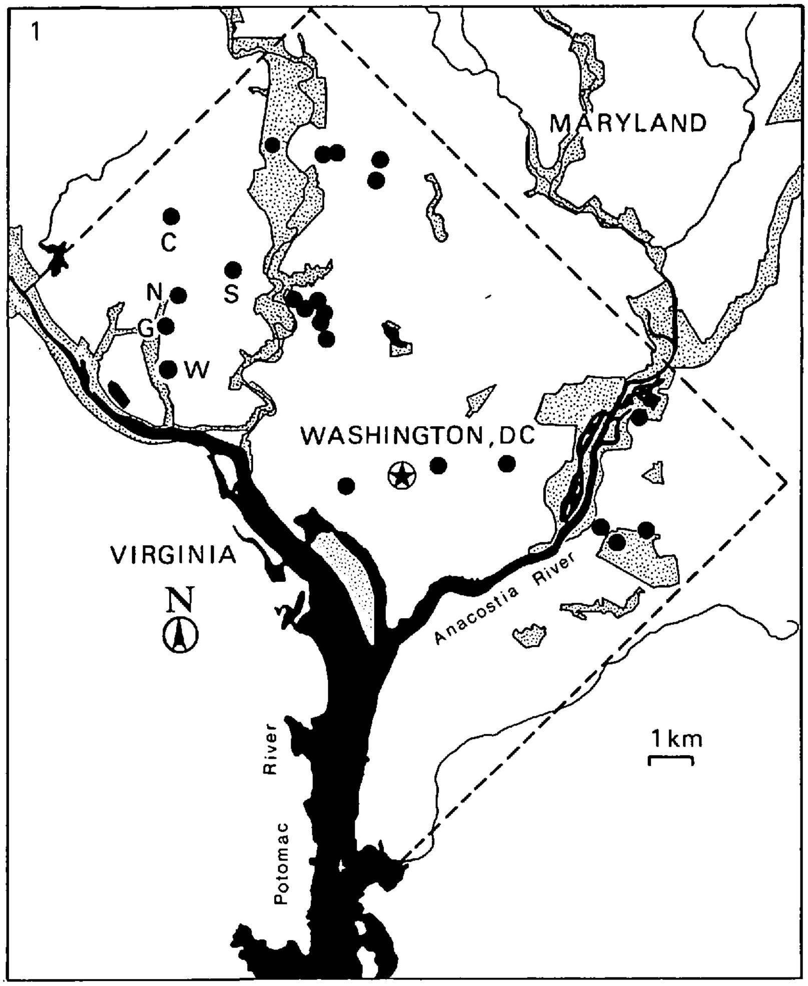

FIG. 1.—Locations of vegetable gardens: (C) Chesapeake Street garden; (G) Glover Park garden; (N) Newark Street garden; (S) Sedgwick Street garden; (W) W Street garden. Parks and national forests are stippled. Black dots that are not accompanied by letters indicate locations of the other community vegetable gardens that we did not study.

bags with fresh bean leaves until they either mummified due to *P. foveolatus* parasitization, died from other causes, or matured into nonparasitized adults. The sexes of emerged wasps were ascertained by examination with a dissecting microscope; percentages of males were calculated from counts of these wasps. No quantitative data were taken on from gardens in which we did not release *P. foveolatus* in 1979.

In 1979, from three to six sampling sites in bean patches with MBB larvae were established in each garden (Fig. 2). A mean of 10.3 ± 0.14 large 3rd and 4th instars and prepupae of MBBs were collected from each site from weeks 1 to 9.

In 1980, *P. foveolatus* were released in the Glover Park garden, and the remaining four gardens served as controls (gardens in which we did not release them). We attempted to obtain samples of a total of 10 large 3rd- and 4th-instar and prepupal MBBs from the central and peripheral areas of each of the five gardens. Samples were taken during weeks 4, 7, and 9 after wasp release in the Glover Park garden. When later-instar MBBs could not be found, early instars were collected and reared to ascertain whether or not they were parasitized by *P. foveolatus*. The wasps prefer to oviposit in older larvae but will parasitize younger ones when there are no older ones.

Standard errors are indicated after means. The Kendall coefficient of rank correlation, tau, was used to analyze data for possible correlations. The Fisher exact probability test and the χ^2 test for goodness of fit were used to test for possible differences between two samples.

Results and Discussion

In 1979 no parasitism of MBBs by *P. foveolatus* was detected from samples that were collected in week 0 (the week during which the wasps were released). In week 1, there were from 0 to 55 parasitized MBBs per release site (15.6 ± 10.33, n = five gardens). Although gardeners inadvertently re-

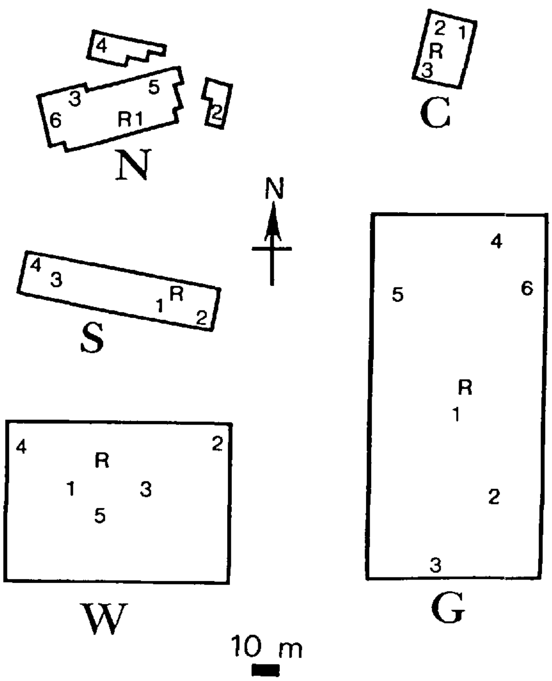

FIG. 2.—Study gardens. (R) release site of wasps; (1) sampling site 1; (2) sampling site 2, etc., in 1979.

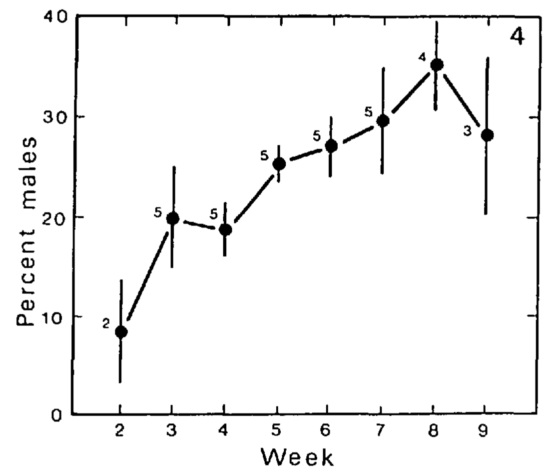

FIG. 4.—Mean percentages of males of wasps during weeks 2 to 9. Vertical lines represent 1 SE. Numbers next to mean dots refer to the number of gardens from which wasps could be obtained. From 17 to 1,019 (381.2 ± 48.76) wasps were sampled in each garden per week.

moved beans at two sites and applied a pesticide dust at one of the release sites, the *P. foveolatus* population increased in each garden and caused 100% parasitism in sampled MBBs in week 3 (Chesapeake), week 7 (Newark), and week 8 (W and Sedgwick). In week 9, 98% parasitism occurred in the Glover Park garden. Figure 3 shows the weekly increase to 99% in the 5 gardens. A total of 217 samples of from 1 to 16 MBB larvae (10.3 ± 0.14) were

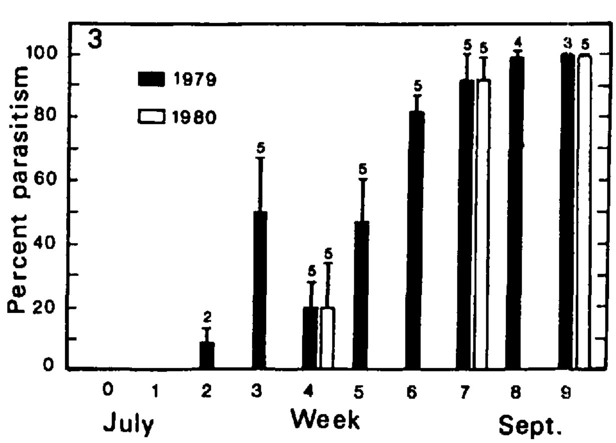

FIG. 3.—Mean percentages of beetle larvae that were parasitized by the wasps during the week of wasp release (week 0) and 9 subsequent weeks. Vertical lines indicate 1 SE, and numbers over bars refer to the number of gardens from which wasps could be obtained.

examined. Percent parasitism was positively correlated with time ($P = 0.01$). The drop in parasitism from week 3 to 4 may be related to a decline in the number of MBB larvae at the end of the beetle's first generation. Data from 1980 (see Fig. 6) reveal that *P. foveolatus* from Maryland may have entered two of the control gardens as early as mid-July. Thus *P. foveolatus* that we put in gardens in 1979 may have been supplemented with ones from Maryland. In 1979 by week 2 or 3, the highest percentage of parasitism was in sampling sites nearest to or second nearest to release sites, suggesting that our released *P. foveolatus* were the only ones or the most frequent ones in gardens in weeks 2 and 3 and possibly later.

The percentage of male *P. foveolatus* increased in general in the gardens during the 3-month sampling period in 1979 (Fig. 4) and was positively correlated with time ($P < 0.001$). Our positive correlation substantiates the study of Stevens et al. (1977). The percentage of males also increased with the number of adult wasps emerging per beetle (Fig. 4). However, in our study, the correlation between the percentage of male *P. foveolatus* and the number emerging per MBB was not significant ($P = 0.258$). Nonetheless, the correlation in the data of Stevens et al. (1977) was significant ($P < 0.01$). Differences in times of sampling, beetle food, and habitats probably account for some of the differences in results of these two studies. Both studies show a similar trend in the region of Fig. 5 where we both have data. Each percentage of males is based on from 70 to 2,834 wasps (817.9 ± 22.70) from 1 to 160 MBB mummies (44.2 ± 14.28). When the number of *P. foveolatus* is greater than 50, the percentage of males in our data appears to level off, and this leads to a lower correlation. Stevens et al. (1977) reported no data when the number of wasps per MBB was >50. In all of our groups in which from 1 to 20 wasps

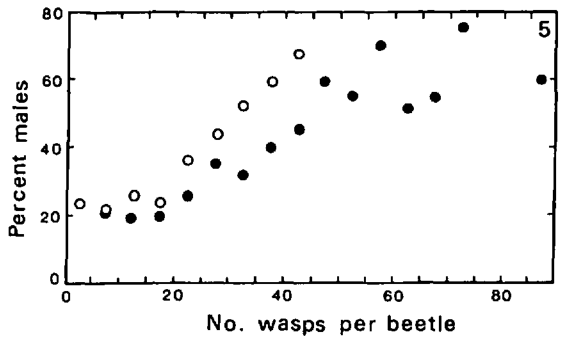

FIG. 5.—Percentage of emerging wasps that were males with respect to the number of wasps emerging per beetle. Symbols: O, data from Stevens et al. (1977); ●, our data.

emerged per beetle, three was a mean of 18.8% males. Stevens et al. (1977) found 23.3% males in such groups, conjecturing that cases with >20 wasps emerging per MBB result from multiple ovipositions by *P. foveolatus* that occur when MBB populations decline or are small. Furthermore, they discuss possible reasons for change in percentage of males with respect to the number of wasps emerging per beetle, including differential sex determination by egg-laying females and differential survival of the sexes.

From July to September 1979, the area planted in beans decreased from 46.7 to 80.6% (62.1 ± 7.66) in all five gardens. Based on discussions with and observations of gardeners, there are two main reasons for this decrease. First, many experienced gardeners do not plant a late summer crop of beans because they remember high populations of pestiferous MBBs at this time in past years. Second, many less-experienced gardeners tend to decrease the time that they spend gardening and plant fewer vegetables as the season progresses.

In 1980, MBBs were sampled for *P. foveolatus* parasitization in weeks 4, 7, and 9 weeks after release of these wasps in the Glover Park garden. There was no significant difference in average frequency of parasitism between years in all five gardens in these 3 weeks (Fig. 3, $P < 0.05$, test for equality of 2 percentages), even though *P. foveolatus* were released in only one garden in 1980. In contrast in individual gardens, percent parasitism was significantly different nine times between years (Fig. 6). In week 4, the percent parasitism in the Sedgwick garden was even significantly higher ($P < 0.001$) than that of the Glover Park garden. Either a founding population of *P. foveolatus* moved into the Sedgwick garden, they overwintered in the garden, or both. If wasps cannot overwinter in the city, many if not all of the *P. foveolatus* that founded subpopulations in the Chesapeake, Newark, Sedgwick, and W Street gardens probably came from Maryland soybean fields, the Glover Park garden, or both. Wasps reduced MBB numbers earlier in 1979 than in 1980 in the Chesapeake and W Street gardens in 1979 in week 9 until killing frosts, new bean leaves without MBB damage were common in both years. In 1980

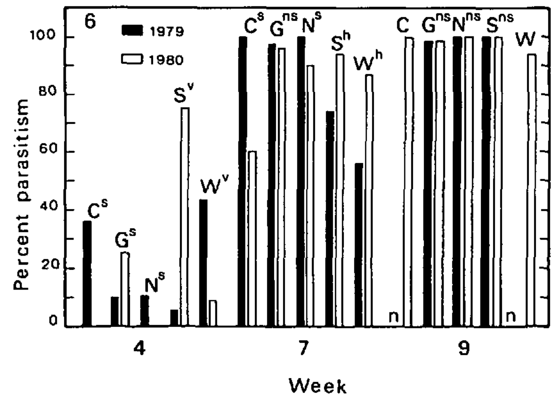

FIG. 6.—Percent parasitism of beetles by wasps in individual gardens in weeks 4, 7, and 9. C, G, N, S, and W indicate gardens as in Fig. 1. h, Highly significant ($P < 0.01$); n, no beetle larvae found; ns, not significant ($P > 0.05$); s, significant ($P < 0.05$); v, very highly significant ($P < 0.001$). Significance levels refer to comparisons that are within gardens and between years.

in week 14 post wasp release, no living MBB larvae could be found and bean plants were thriving.

In conclusion, our study suggests that if *P. foveolatus* were introduced into urban gardens at the appropriate times (e.g., late June in the Washington, D.C., area), summer and fall beans would have very few or no MBB larvae. This should encourage gardeners to increase garden productivities by planting more beans from mid- to late summer. Moreover, using *P. foveolatus* as a biocontrol agent could markedly reduce use of possibly injurious pesticides in these gardens because the MBB is a principal pest that gardeners attempt to control with chemical pesticides. This beneficial wasp also fatally parasitized a minor pest, the squash beetle, *E. borealis* (F.), in the study gardens. *P. foveolatus* should be widely used by gardeners wherever MBBs and squash beetles are problems.

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