Mexican Bean Beetle (Coleoptera: Coccinellidae) Larval Parasite *Pediobius foveolatus* (Hymenoptera: Eulophidae) from Japan: Field Release in the United States[1]

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ABSTRACT A Japanese race of the parasite *Pediobius foveolatus* (Crawford), with its origin in Okayama Prefecture, Honshu, was released in 1980 against the Mexican bean beetle, *Epilachna varivestis* Mulsant, at 43 sites (31 in Indiana) in eight U.S. midwestern states to test for parasite overwintering. Post-release reproduction was confirmed at 19 sites in six states. However, in 1981, there was no evidence of successful parasite overwintering. This was attributed to the unavailability of suitable host stages or inability of adults to survive the winter months.

In 1956, George Angalet, USDA overseas explorer, first investigated *Pediobius foveolatus* (Crawford) (Hymenoptera: Eulophidae) in India and later requested that live material be sent to the United States from Bangalore (Angalet et al. 1968). In 1966, 1972, and 1973 a total of 10 shipments of *P. foveolatus* were received at the Beneficial Insects Research Laboratory (BIRL), Newark, Del. (before 1973, located at Moorestown, N.J.). Material from these shipments was the source of all colonies of *P. foveolatus* which are currently used for annual inoculative releases. This annual release program is necessary, since *P. foveolatus* is not known to overwinter successfully in North America. Beginning in Maryland in 1972, use of this parasite for biological control of Mexican bean beetle (MBB), *Epilachna varivestis* Mulsant (Coleoptera: Coccinellidae), was attempted (Stevens et al. 1975a), and the promising results attained prompted other states (Delaware, New Jersey, Virginia, and limited releases in Idaho, West Virginia, and Massachusetts in 1981) to participate in programs modeled after the work in Maryland.

In an ongoing effort to establish exotic beneficial agents for the biological control of MBB, a more temperate race of *P. foveolatus* from Japan has been imported and released. Presence of the parasite in Japan was first recorded in 1970 at Kyoto, Honshu, where it was reared from *Henosepilachna vigintiomaculata* (Motschulsky) and *Henosepilachna vigintiopunctata* (F.) (Tachikawa 1976). Schaefer, then assigned to USDA, Asian Parasite Laboratory (APL), Sapporo, Hokkaido, Japan, was able to ascertain that adequate numbers of *P. foveolatus* could be collected in Honshu. In August 1979, Ikebe, also of APL, successfully shipped *P. foveolatus* (hereafter referred to as the Japanese or J race) to BIRL quarantine. It was easily reared on larvae of MBB, and laboratory tests confirmed cross mating with an Indian strain (hereafter referred to as "Indian" or "I" race). The two cultures were morphologically indistinguishable, with very similar functional, developmental, and behavioral traits. Taxonomists confirmed that both populations were conspecific, differing by virtue of their origins. The two races (J and I) have been maintained in culture at BIRL to date (August 1982).

Field releases of J race in various midwestern states are reported here in an effort to determine overwintering ability. The rationale for this effort hinges on the temperate-region origin (35° N latitude) of the J race, whereas the I race originated in the tropics (13° N). States in the Midwest and the Mississippi River valley (from 30 to 43° N) were selected to avoid contamination with concurrent releases of I race in several Atlantic coastal states in continuing efforts to achieve biological control of MBB on soybean and snapbean crops.

Materials and Methods

Field release plots were prepared by personnel of various cooperating federal, state, university, and private organizations. Field personnel were requested to: (1) position nurse plots near soybean fields and hedge rows or windbreaks, (2) plant with locally adapted snapbeans alone or in mixtures with soybean, (3) plant seed somewhat early relative to normal planting dates for local conditions, and (4) cultivate as in customary practice. In Indiana some releases were made directly into soybean fields without the benefit of specially prepared nurse plots.

From the J race maintenance culture at BIRL, a subculture was provided to USDA, APHIS-PPQ, Biological Control Satellite Facility, Niles, Mich., in early 1980. There, the culture was propagated by methods similar to those of Stevens et al. (1975b), and shipments of 50 mummies per release container were provided for scheduled releases. Except for those in Indiana, releases were done by BIRL personnel. Shipments to Flanders in Indiana, were for dispersal assessments (those aspects of

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releases are not reported herein), but these releases represented adequate release sites wherein overwintering might occur.

Several weeks after parasite releases, special efforts were made to ascertain if reproduction of *P. foveolatus* had occurred in the release plots. In July 1981, Schaefer made attempts to recover the parasite. Visual inspection of the plants for characteristic parasite mummies was used most frequently; however, in low host populations host larvae were either collected and later (1) dissected to determine if parasite larvae were present, or (2) reared on a diet of snapbean foliage to ascertain if they were parasitized (Missouri locations). The J race of *P. foveolatus* was field released in 1980 at 31 sites in Indiana and 15 additional sites in seven states from Mississippi to Wisconsin.

Results and Discussion

Postrelease checks indicated that the parasite had reproduced itself at 13 sites in Indiana and 11 additional sites in five other states during the season of release (Table 1).

In Indiana, no parasite populations were found at any site where releases were made directly into soybean fields. Procedures utilized were designed to maximize parasite propagation after release and thereby optimize the chances of overwintering by the greater numbers of parasites available as winter approached.

In July 1981, recovery attempts were made primarily in Wayne, Fayette, Union, and Lawrence Counties in Indiana and at all other release sites where postrelease reproduction had been confirmed. In 1981, the J race was used in the remaining Indiana areas, and recovery of the J race was only attempted early in the season before any 1981 releases. Although several techniques were used, the *P. foveolatus* J race was not recovered at any release site in 1981.

It is possible that *P. foveolatus* J race overwintered but was not detected in the recovery attempts, since the parasites might have dispersed to nearby sites which were not surveyed or individuals were present at such low densities they were not detected. In Indiana, very low densities of MBB occurred in soybean fields during 1981 because of prolonged spring rains and the consequent late planting of fields. Early-season recovery attempts were thus hindered, but late in the season MBB larvae were found at all recovery sites. Project personnel are reasonably sure that recovery would have occurred had the parasite been present.

One site, in addition to several Indiana sites, represented the most likely locale for overwintering based on parasites present during the season of release. At Lincoln County, Tenn., 4 days after the initial parasite release, the snapbeans were almost completely defoliated by severe MBB populations, and abundant mature host larvae (63 larvae per 0.91 m of row) moved out into surrounding soybeans. On 7 July 1980, parasite mummies were found in the soybeans (seven well-formed mummies found in a 40-m row). Soon thereafter, local APHIS personnel reported that mummies were common and any threat to soybeans by the abundant MBB larvae had diminished appreciably. Later in the season, parasites were abundant. With such favorable conditions in 1980, it was distinctly different in 1981. The MBB pop-

Table 1. Location of 1980 field releases of Japanese race of *P. foveolatus*, a larval parasite of MBB, with number of parasites released and confirmation of postrelease reproduction

State	County	Town[a]	No. released	Parasite reproduced[a]
IL	Hancock	Carthage	200	
KY	Caldwell	Princeton	625	+
MS	Copiah	Crystal Springs	600	+
MS	Lee	Verona	450	
MS	Pearl River	Poplarville	700	
MS	Perry	Beaumont	675	+
MO	Boone	Colombia (3)	390	+ (3)
MO	St. Louis	Ferguson	190	+
TN	Dyer	Dyersburg	400	
TN	Lincoln	Vanntown	1,400	+
WI	Dane	Madison (2)	1,400	+ (2)
IN	Wayne	Richmond (3)	3,808	+ (1)
IN	Fayette	Connersville (3)	8,381	+ (2)
IN	Union	Liberty (2)	850	+ (1)
IN	Bartholomew	Columbus (4)	5,848	+ (1)
IN	Jennings	North Vernon (3)	6,579	+ (2)
IN	Jackson	Brownstown (3)	7,004	+ (2)
IN	Jefferson	Madison (3)	5,168	+ (1)
IN	Scott	Scottsburg (3)	1,020	
IN	Clark	Jeffersonville (2)	10,030	+ (2)
IN	Montgomery	Crawfordsville (2)	1,275	
IN	Putnam	Greencastle (2)	1,275	
IN	Lawrence	Bedford	850	+
MI	Berrien	Niles	200	+

[a]Parentheses show number of multiple-release sites.

ulation was moderately high on 16 July when new adults were common. Snapbeans were defoliated, and pupal exuviae on fallen bean leaves littered the ground. During a thorough search for mummies on these fallen leaves, only pupal exuviae were present. We can only conclude that the parasite did not overwinter there successfully.

Other sites possessed appreciably lower numbers of MBB. With the exception of Perry County, Miss., MBB life stages were found in 1981 in all sites where parasite reproduction was confirmed in 1980 (Table 1).

In the future, it will be impossible to repeat such a release and recapture attempt, since *P. foveolatus* (I race) is now commercially available. Package parasites are sold to farmers and home gardeners, and since it remains impossible to distinguish the two races, it will also be impossible to confirm successful overwintering since any nearby annual releases will result in a false report.

There is now reason to believe that the ability of the parasite to overwinter may depend on the availability of overwintering larvae of suitable species in the Epilachninae. The inability to establish *Apolmyiopsis* (= *Paradexodes) epilachnae* (Aldrich) (Diptera: Tachinidae) in the United States during the 1920s and 1930s was similarly attributed to the unavailability of suitable MBB stages during the winter months (Clausen 1956, Landis and Howard 1940). In Pakistan, *P. foveolatus* has been recorded overwintering in larvae of *Epilachna* sp. nr. *ocellata* Redt. (CIBC 1979). In Japan, *Epilachna admirabilis* Crotch overwinters in the larval stage although *P. foveolatus* overwintering in this host has not been confirmed. Thus in Asia, there are potential host species which overwinter as larvae. In eastern North America, our three species in the Epilachninae [MBB, squash beetle, or *Epilachna borealis* (F.), and *Subcoccinella vigintiquatuorpunctata* (L.), newly established from Europe (USDA 1974)], all overwinter as adults.

If *P. foveolatus* can overwinter only in Epilachnine host larvae, then annual parasite releases may be the only method of utilizing this parasite against the MBB.

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