Exploitation of Eggs of the Colorado Potato Beetle, *Leptinotarsa Decemlineata* (Coleoptera: Chrysomelidae), by the Exotic Egg Parasitoid *Edovum Puttleri* (Hymenoptera: Eulophidae) in Eggplant

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EXPLOITATION OF EGGS OF THE COLORADO POTATO BEETLE, *LEPTINOTARSA DECEMLINEATA* (COLEOPTERA: CHRYSOMELIDAE), BY THE EXOTIC EGG PARASITOID *EDOVUM PUTTLERI* (HYMENOPTERA: EULOPHIDAE) IN EGGPLANT

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ABSTRACT

Edovum puttleri is a newly discovered, exotic, egg parasitoid of the Colorado potato beetle, (CPB) *Leptinotarsa decemlineata*. The exploitation of CPB eggs by *E. puttleri* was examined in a New Jersey eggplant field. *E. puttleri* parasitized 46.8% of the CPB eggs present in the field. Exploitation of eggs within eggmasses was high; 73.9% of CPB eggs in eggmasses attacked by *E. puttleri* were parasitized.

The Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (CPB), is the major insect pest of potato, tomato, and eggplant crops in much of North America. Both larval and adult stages of the CPB feed on solanaceous crops, and outbreaks of this pest can substantially reduce crop yields (Schalk and Stoner 1979, Hare 1980). Despite its yield-limiting potential, development of integrated pest management programs for the CPB has been slow, hampered chiefly by lack of effective natural enemies (Harcourt 1971) and increasing insecticide resistance (Forgash 1981, Gauthier et al. 1981).

Lack of reliable natural and chemical controls for the CPB has stimulated research into cultural (Lashomb and Ng 1984) and microbial controls (Cantwell et al. 1983, Watt and LeBrun 1984) and has fueled the search for exotic insect enemies. Recent natural-enemy explorations of Central and South America, the center of origin of the genus *Leptinotarsa* (Hsiao 1978), have discovered two potential candidates for CPB integrated management programs: a race of *Chrysomelobia labidomerae* Eickwort, an ectoparasitic mite of adult CPB (Drummond et al. 1984), and the egg parasitoid *Edovum puttleri* Grissell (Hymenoptera: Eulophidae). *E. puttleri* was originally collected from eggs of *L. undecimlineata* (Stål) in Colombia (Grissell 1981) but laboratory studies have found that this parasitoid can successfully parasitize eggs of the CPB (Puttler and Long 1983). Moreover, *E. puttleri* is genus-specific (Puttler and Long 1983), easily reared in the laboratory (Schroeder et al. 1985), and, although Neotropical and intolerant of temperate-zone winters (Obrycki et al. 1985), shows promise for yearly inoculative or inundative release against the CPB.

Previous studies have considered the integration of *E. puttleri* into potato and tomato agroecosystems, particularly in relation to CPB-resistant potato species (Obrycki et al. 1985) and microbial insecticides (Cantwell et al. 1985). However, studies of the impact of *E. puttleri* on CPB egg and eggmass populations in potato and tomato have given conflicting results. Obrycki et al. (1985) found that *E. puttleri* parasitized 41% of CPB eggs on potato plants in outdoor cage studies. An additional 50% of CPB eggs present in the cages failed to hatch, possibly a result of mortality incurred by *E. puttleri* host

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feeding. In contrast, Cantwell et al. (1985) determined that inoculative releases of *E. puttleri* were ineffective in reducing the number of CPB eggmasses occurring in tomato plots. Unfortunately, comparisons between the results of Obrycki et al. (1985) and Cantwell et al. (1985) are difficult to make owing to differences in study objectives and design, and the levels of scale at which parasitism was assessed (e.g., eggmasses vs. eggs within eggmasses).

The lack of information concerning use of *E. puttleri* as a potential biological control of the CPB in eggplant (*Solanum melongena* L.) provided the impetus for this study. In commercial growing regions, the CPB may cause severe damage to eggplant crops, resulting in reduced yields (Cotty and Lashomb 1982) and increased production costs (see Dhillon 1979 for a breakdown of eggplant production costs in New Jersey). This study provides an initial field assessment of the effects of *E. puttleri* on CPB eggs in eggplant. The objectives of this study were to determine if *E. puttleri* could successfully parasitize eggs of the CPB in eggplant and, if so, to describe the extent of *E. puttleri*'s exploitation of CPB eggs at both egg and eggmass levels.

MATERIALS AND METHODS

The study was conducted in South Brunswick, Middlesex County, New Jersey, during July and August 1983, in conjunction with a larger study of CPB movement and oviposition in eggplant. Eggplant seedlings ('Classic' cv.) were planted at 1.8 m-intervals in rows 1.8 m apart in a 44 by 44-m plot during early June. Granular fertilizer (Osmocote 20-20-20) was applied in furrow during transplant and plants were irrigated regularly throughout the study. Spacing of study plants was greater than commercial spacing (e.g., rows 1.0–1.5 m apart, plants 0.6–1.0 m apart within a row; New Jersey Commercial Vegetables Recommendations [1983]) because of plant spacing requirements for the concurrently run CPB movement and oviposition study.

Fifteen hundred newly emerged, summer generation CPB were collected from a commercial potato field on 19 July and released in the study plot on 21 July. CPB oviposition was monitored two to three times a week by eggmass searches of all plants in the field. The location and condition of each eggmass (hatched, missing, or destroyed by predators) was recorded. Eggmasses were marked by placing a small drop of nail polish on the leaf 3 cm to the left of each eggmass to facilitate discovery in subsequent searches. A different color was used each sample day to accurately monitor eggmass fate. Hatched eggmasses were immediately removed to prevent larvae from defoliating plants.

Five thousand *E. puttleri* adults (Colombian biotype; estimated sex ratio 1:1 male to female) were obtained from the New Jersey Department of Agriculture Beneficial Insect Laboratory (Trenton, NJ) on 27 July. Nothing was known about the dispersal ability of *E. puttleri* before release and, since eggplant flowers lack nectar (Symon 1979) (nectar may slow parasitoid dispersal by providing an attractive food source; Atsatt and O'Dowd [1976]), I hypothesized that there would be some dispersal of *E. puttleri* from the study plot. The release number chosen provided approximately nine parasitoids/plant, a quantity I assumed would provide a buffer against parasitoid losses from the field due to dispersal.

Parasitoids were released in the center of the study plot on 28 July, when field eggmass-density had reached approximately one per plant. The release timing insured the availability of host material for *E. puttleri* utilization and exposed parasitoids to a range of variously aged eggmasses. After parasitoid release, eggmasses were monitored two to three times a week for signs of parasitism (blackened eggs and (or) *E. puttleri* larval development), predation (punctured or shredded egg chorions), and dessication. Egg dessication was of interest because of possible correlation with *E. puttleri* host feeding (Schroeder et al. 1985). Eggmasses were observed in the field with a 10× hand lens to determine the extent of parasitoid exploitation of eggs within eggmasses.

Meteorological data for the study period were obtained from the Department of Meteorology, Rutgers University, for New Brunswick, NJ (12 km north of the study area). Maximum and minimum temperatures were used to calculate degree day accumu-

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Table 1. Summary of the fates of CPB eggs before and after the release of *Edovum puttleri*. Prerelease eggs were present in the study plot during the period of 21–27 July 1983; postrelease eggs were present from 28 July to 10 August 1983.

Fate of eggs	Prerelease	%	Postrelease	%
Hatch	5071	77.6	2601	30.2
Predation	1462	22.4	680	7.9
Dessication	0		1292	15.0
Parasitism	0		4029	46.8

lation (Allen 1976) above 10°C, the developmental threshold of the CPB (Ferro et al. 1985). Eggmass physiological age was considered because of its possible effect upon parasitoid host acceptance.

RESULTS AND DISCUSSION

Edovum puttleri parasitized 46.8% (4029) of CPB eggs present in the field (Table 1), similar to the level of egg parasitism observed by Obrycki et al. (1985) in potato cage-studies. In addition to parasitism, dessication was observed in 15% (1292) of CPB eggs. Dessicated eggs typically appeared shrunken, discolored, and contained little yolk. Evidence of predation was absent in dessicated eggs, and sucking predators (e.g. nabids; Latheef and Harcourt [1974]) were not seen in the study plot. No observations of *E. puttleri* host feeding were made, thus egg dessication cannot be directly ascribed to parasitoid host feeding.

The fate of prerelease eggmasses can be used as a reference for gauging the impact of *E. puttleri* upon CPB egg populations (Table 1). Eclosion occurred in the majority (77.6%) of prerelease CPB eggs (Table 1). The remaining eggs (22.4%) succumbed to predators. Qualitative observations attributed egg predation primarily to *Lebia grandis* Hentz (Coleoptera: Carabidae), *Coleomegilla maculata lengi* Timberlake (Coleoptera: Coccinellidae), and larvae of *Chrysopa carnea* Stephens (Neuroptera: Chrysopidae), all of which are known egg predators (Lingren et al. 1968, Clausen 1976). Adult CPB also occasionally cannibalized eggmasses. Total prerelease egg hatch would have produced an average density of 8.8 CPB larvae/plant, sufficient to cause temporary yield reduction in eggplant (Cotty and Lashomb 1982). In contrast, postrelease egg hatch was lower, producing an average density of 4.5 CPB larvae/plant, a density below the eggplant yield-reduction threshold (Cotty and Lashomb 1982).

Edovum puttleri exploited a high proportion of the CPB eggs within individual eggmasses (Table 2). The majority of eggs (73.9%) in eggmasses attacked by *E. puttleri* were parasitized. Eggs that were not parasitized either were dessicated (23.7%) or hatched CPB larvae (2.4%). There was no evidence of egg predation in parasitized eggmasses. These results indicate that on an eggmass level, exploitation of eggs by *E. puttleri* is high, particularly if egg dessication is caused by parasitoid host feeding. If this high level of utilization of eggs within eggmasses is typical of *E. puttleri*, this attribute may prove useful to biological control programs. For example, field scouts could assess the impact of *E. puttleri* on CPB egg populations by determining the proportions of parasitized and unparasitized eggmasses in a field, multiplying these proportions by the average number of eggs in an eggmass, and computing the potential number of CPB larvae/plant from these data. Appropriate control measures could then be prescribed. Field and laboratory studies under a variety of conditions are needed to further elucidate *E. puttleri* eggmass utilization.

The results of this study demonstrate that at the egg population level, *E. puttleri* is capable of moderate levels of CPB egg parasitism in eggplant. When considered at the

Table 2. Summary of the fates of CPB eggs within eggmasses after the release of *Edovum puttleri*.

Number of eggmasses	Fate of eggs in eggmass	Number of eggs	Percent of total	$\bar{x} \pm SE$ eggs/eggmass
313	hatched	131	2.4	0.41 ± 0.05
	dessicated	1292	23.7	4.13 ± 0.76
	parasitized	4029	73.9	12.87 ± 1.26
193	hatched	2470	78.4	12.80 ± 1.93
	predated	680	21.6	3.52 ± 0.68
31	not recovered	—	—	—

eggmass level, exploitation of CPB eggs is high within eggmasses but patchy among eggmasses; some eggmasses escape parasitism while others are devasted by the parasitoid. Thus it appears that host acceptance by *E. puttleri* is at the eggmass level; if the majority of eggs within the eggmass are found suitable by the parasitoid, utilization of eggs is high. Factors that influence host acceptance by *E. puttleri* are currently unknown, but it is probable that eggmass physiological age is an important determinant as it is in other egg parasitoids (Lewis and Redlinger 1969, Fedde 1977). Eggmasses of varied physiological age (ranging in age from freshly laid to > 90 degree days) were present in the field at the time of *E. puttleri* release, but no distinct pattern of host age preference could be determined from the data. Perhaps acclimation of the parasitoid to conditions in the field confounded attempts to correlate parasitism with host age.

Edovum puttleri shows promise as a biological control for the CPB in eggplant. Further research is needed, however, before *E. puttleri* can be successfully included in CPB integrated pest management programs. In particular, information on host age preference, extent of host feeding, reproduction in the field, and the economics of mass rearing will determine whether *E. puttleri* is a viable biological control for the CPB.

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