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INTRODUCED PARASITES OF *AGROMYZA FRONTELLA* (RONDANI)[1] IN THE USA

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Abstract.—From 1974 to 1978, we released 14 species of European parasites (ca. 82,000 insects from 3 agromyzid host species on alfalfa) as part of a biological control effort against the alfalfa blotch leafminer, *Agromyza frontella* (Rondani), in the USA. A list of release locations, dates, and parasite numbers is presented. Techniques for rearing 4 of the species are briefly described. Two species, *Dacnusa dryas* (Nixon) (Hymenoptera: Braconidae) and *Chrysocharis punctifacies* Delucchi (Hymenoptera: Eulophidae), have been established in Delaware. Sufficiently large field populations of these species were present in 1978 so that insects were collected by sweeping and moved to other release locations.

The alfalfa blotch leafminer (ABL), *Agromyza frontella* (Rondani), a pest of European origin first reported in the USA in Massachusetts in 1968 (Miller and Jensen, 1970), is now found throughout the northeastern states and adjacent Canadian provinces. The USDA began the introduction of parasites for biological control of this pest in 1974. The purpose of this paper is to document parasite releases and recoveries.

Sources of parasites released.—Foreign parasite material was provided by the USDA European Parasite Laboratory, Sèvres, France. The material was received at our laboratory quarantine facility as adults or as immatures in host puparia. Several parasite species were reared successfully in the laboratory, and releases were made from these cultures. By 1978, 2 species of parasites, *Dacnusa dryas* (Nixon) and *Chrysocharis punctifacies* Delucchi, became so abundant in local fields that they were collected by sweeping and moved to new release locations. The order, family, and determiner of all parasite and host species mentioned in this paper are listed in Table 1. Releases of 14 species of European parasites (ca. 82,000 insects from 3 agromyzid host species on alfalfa) against ABL were made from 1974 to 1978. The species, numbers, and locations are found in Table 2.

Techniques for rearing parasite species.—We attempted to rear nearly all of the 14 parasite species but were successful with only 4 of them. (Since the use of ABL as a host means that considerable space must be provided for potted alfalfa and relatively few ABL per plant are produced, we used alternate hosts whenever possible.)

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[1] Diptera: Agromyzidae.

Table 1. Order, family, and determiner of species mentioned in this paper.

Species
HYMENOPTERA: BRACONIDAE
Chorebus poss. *misellus* (Marshall)[a]
Dacnusa dryas (Nixon)[a]
Dacnusa maculipes Thomson[a]
Dacnusa sp.[a]
Dapsilarthra balteata (Thomson)[e]
Opius dureseaui Fischer[a]
Opius maculipes (Thomson)[a]
Phanomeris braconius (Haliday)[a]
HYMENOPTERA: EULOPHIDAE
Chrysocharis naenia (Walker)[f]
Chrysocharis punctifacies Delucchi[f]
Diglyphus intermedius (Girault)[b]
Diglyphus isaea (Walker)[b]
HYMENOPTERA: PTEROMALIDAE
Halticoptera circulus (Walker)[f]
Miscogaster hortensis Walker[d]
Miscogaster maculata Walker[d]
DIPTERA: AGROMYZIDAE
Agromyza frontella (Rondani)[c]
Agromyza nana Meigen[c]
Agromyza parvicornis Loew[c]
Liriomyza congesta (Becker)[c]
Liriomyza trifoliearum Spencer[c]

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Chrysocharis punctifacies, a solitary endoparasite of larvae, emerging from puparia, was successfully reared on ABL by placing adult parasites in cages containing alfalfa plants that had mining larvae in the leaflets. After the parasites oviposited, the plants were laid on their sides so mature parasitized hosts dropped from the leaflets into trays of moist vermiculite from which they eventually emerged. This is a slight modification of the tipped plant method for rearing ABL described by Hendrickson and Barth (1977). The parasite also oviposited readily on *Liriomyza trifoliearum,* reared on bean plants, but this leafminer invariably died after transforming to the pupal stage, and no parasites developed.

Dacnusa dryas, another solitary endoparasite of larvae, emerging from puparia, was successfully reared on ABL by using the same techniques

Table 2. Releases of European parasites against the alfalfa blotch leafminer in the USA. Original host species are indicated in footnotes.

State	County	Locality	Release year (19—)	No.
Chorebus poss. *misellus*[a,c]				
Delaware	New Castle	Newark	77	132
Chrysocharis naenia[b,c]				
Delaware	New Castle	Newark	77	28
New Jersey	Warren	Blairstown	78	5
			Total	33
Chrysocharis punctifacies[a]				
Delaware	New Castle	Newark	77	1,277
			78	217
New Jersey	Burlington	Rancocas	78	100
	Warren	Blairstown	78	35
New York	Cortland	Cortland	78	255
	Dutchess	Standfordville	78	16
	Herkimer	Mohawk	78	163
	Tompkins	Dryden	78	338
Ohio	Ashtabula	Padanaram	78	29
Pennsylvania	Chester	Kemblesville	78	10
		New London	78	10
		Oxford	77	66
			78	791
			Total	3,307
Dacnusa dryas[a]				
Delaware	New Castle	Newark	77	620
			78	596
New Jersey	Burlington	Rancocas	77	12
			78	156
	Warren	Blairstown	78	126
New York	Cortland	Cortland	78	1,839
	Dutchess	Stanfordville	78	30
	Herkimer	Mohawk	78	254
Ohio	Ashtabula	Padanaram	78	21
Pennsylvania	Chester	Kemblesville	78	50
		New London	78	50
		Oxford	77	55
			78	1,398
			Total	5,207
Dacnusa maculipes[b,c]				
Delaware	New Castle	Newark	77	352
Pennsylvania	Chester	Oxford	77	13
			Total	365

Table 2. Continued.

State	County	Locality	Release year (19—)	No.
Dacnusa sp.[a,b,c]				
Delaware	New Castle	Newark	76	10
			77	653
New Jersey	Burlington	Rancocas	77	97
Pennsylvania	Chester	Oxford	77	139
			Total	899
Dapsilarthra balteata[a,c]				
Delaware	New Castle	Newark	77	50
			78	3
Pennsylvania	Chester	Oxford	78	7
			Total	60
Diglyphus isaea[a,b,c]				
Delaware	New Castle	Newark	75	2,000
			76	16,295
Maryland	Cecil	Fair Hill	75	600
			76	2,000
Massachusetts	Hampshire	Hadley	75	600
New Hampshire	Grafton	Concord	75	600
New Jersey	Burlington	Rancocas	75	1,850
			76	13,800
	Warren	Blairstown	75	1,150
			76	2,500
New York	Orange	Windsor	75	400
Pennsylvania	Chester	Kemblesville	75	50
		New London	75	1,400
			76	4,000
		Oxford	75	950
			76	17,950
	Schuylkill	Port Clinton	75	400
			Total	66,545
Halticoptera circulus[a]				
Delaware	New Castle	Newark	78	5
Miscogaster hortensis[a] and *M. maculata*[d]				
Delaware	New Castle	Newark	75	34
			76	5
			77	355
			78	270
Ohio	Ashtabula	Padanaram	78	3
Pennsylvania	Chester	Oxford	77	70
			78	110
New Jersey	Burlington	Rancocas	78	8
	Warren	Blairstown	78	30

Table 2. Continued.

State	County	Locality	Release year (19—)	No.
New York	Cortland	Cortland	78	34
	Herkimer	Mohawk	78	3
	Tompkins	Dryden	78	71
			Total	993
Opius dureseaui[a,b]				
Delaware	New Castle	Newark	75	22
			77	127
			78	20
New Jersey	Warren	Blairstown	75	16
New York	Cortland	Cortland	78	51
	Herkimer	Mohawk	78	52
Ohio	Ashtabula	Padanaram	78	8
Pennsylvania	Chester	Oxford	78	13
			Total	309
Opius maculipes[b]				
Delaware	New Castle	Newark	77	10
Pennsylvania	Chester	Oxford	78	45
			Total	55
Phanomeris braconius[a,b]				
Delaware	New Castle	Newark	75	20
			76	320
			77	1,494
			78	741
New Jersey	Burlington	Rancocas	74	107
			77	148
			78	240
	Warren	Blairstown	74	8
			77	16
			78	190
		Hope	77	40
	Sussex	Vernon	74	31
Pennsylvania	Chester	Oxford	76	20
			77	352
			78	357
		Landenberg	77	32
			Total	4,116

[a] *Agromyza frontella*.
[b] *Agromyza nana*.
[c] *Liriomyza congesta*.
[d] Host relationships are uncertain due to a recent determination that 2 species of *Miscogaster* were involved, rather than an initial determination of 1 species.

described for *C. punctifacies*. When the parasite was exposed to *L. trifoliearum* on bean plants, only a few males were produced. However, both sexes emerged from *L. trifoliearum* collected at the laboratory field in 1978.

Diglyphus isaea, a larval ectoparasite of ABL, was initially reared on ABL infesting potted alfalfa plants. Once the parasites had oviposited on these larvae, the alfalfa stems were cut, and placed in emergence cages, and allowed to dry out. However, production of these parasites was limited by the relatively small numbers of host larvae available on potted alfalfa plants. Later, an easier and more productive method of rearing on *L. trifoliearum* on bean plants was devised (Hendrickson, 1975). In either case, the parasite had to be provided with 3rd-(mature) instar host larvae since it killed 1st- and 2nd-instar larvae by probing, usually without ovipositing.

Phanomeris braconius, a larval ectoparasite, was successfully reared on ABL by the methods described for *D. isaea*. Thus *L. trifoliearum* on bean plants was an acceptable host, but the technique was inefficient because the emerging parasites were small and too many host larvae developed into adult flies. Best results were obtained by rearing *P. braconius* on *Agromyza parvicornis*, a native pest of corn. After the parasites had oviposited on the host larvae, the corn culms (ca. 30-cm tall) were cut, placed in an emergence cage, and dried. Honey was provided as food for emerging parasites. The parasites obtained were slightly larger than those that developed on ABL.

Parasite establishments.—The following species were released at the laboratory alfalfa field in 1977 and recovered by rearing from ABL or by sweeping in 1978. The sampling and emergence techniques employed were described by Hendrickson and Barth (1979).

Dacnusa dryas was released at a rate of 750/ha. The parasite was first recovered from samples collected June 26, 1978 (2nd-cutting alfalfa) and was collected from subsequent samples through November. *Dacnusa dryas* was the most abundant parasite species during the period June 26–30, when it parasitized 14% of the ABL. On the basis of number of stems per m^2, number of mines per stem, and percentage of mines producing the parasite, we calculate that this peak emergence resulted in ca. 175,000 host larvae/ha later producing the parasite species. The rapid rate of increase in only a year is probably a result of a relatively high rate of parasite fecundity and the occurrence of 5 generations of ABL per year in the Delaware area.

Parasite adults were collected by sweeping (maximum recovery rate was 35/100 sweeps) and moved to other release locations. At first we aspirated the *D. dryas* adults from the sleeve cages where we placed the field material from the 100 sweeps. This procedure was time consuming, and separation of *D. dryas* from other insects was difficult. It was more efficient to put the unseparated field material from 1,000 sweeps (collected 200 at a time) into a large, styrofoam container cooled by a freeze pack wrapped in paper

towels. Then the material was taken to a release location. Mortality of material handled in this manner appeared to be slight.

Chrysocharis punctifacies was released at a rate of 190/ha in 1977. The parasite was first recovered on July 17, 1978 (3rd-cutting alfalfa) and was reared from samples collected through September. It was the most abundant parasite species during Sept. 18–22 when it parasitized 34% of the ABL. Adults were collected by sweeping (maximum recovery rate was 5/100 sweeps) and moved to release locations. We had the same difficulty separating adult *C. punctifacies* from field-collected material as we had in separating *D. dryas,* but in addition, several common native *Chrysocharis* species cannot be distinguished from *C. punctifacies* except under the microscope. Again this species was more efficiently disseminated locally by mass collections. However, we unexpectedly recovered a few *C. punctifacies* from field-collected *L. trifoliearum*. Possibly size of host explains our inability to rear the parasite in the laboratory (field-collected insects are larger than laboratory-reared specimens).

Parasites of uncertain establishment status.—A total of 86 *Miscogaster hortensis* and *M. maculata,* solitary endoparasites of larvae, emerging from puparia, was released in 1975–77 at the laboratory alfalfa field (release rate was 85/ha). (The European host relationships for *Miscogaster* spp. in Table 2 are uncertain because the initial determination was that only a single species was involved; later examination of a more extensive series of specimens indicated 2 species were involved.) No *Miscogaster* spp. emerged from samples collected in 1978, but several adult *M. hortensis* were collected by sweeping. Although the species has survived at least one winter, we believe recovery was too low to warrant a claim of establishment. The species may eventually become sufficiently abundant for unquestioned establishment and it may produce significant results.

Miscogaster spp. comprised 15% of the parasites emerging from European ABL puparia processed at the laboratory quarantine facility in 1976–77 and the genus was third in abundance after *C. punctifacies* and *D. dryas* (Hendrickson and Barth, 1979).

Diglyphus isaea, the most abundant parasite of ABL in Europe (J. J. Drea, Jr., pers. com.), was reared in the laboratory and released in large numbers in 1975–76. There were few recoveries in those years and none subsequently. Since *D. isaea* is very similar morphologically to the most abundant North American parasite attacking ABL, *D. intermedius,* we examined the hypothesis that these 2 species had hybridized. Crosses of *D. intermedius* ♀ with *D. isaea* ♂ produced fertile female progeny, but the reciprocal cross produced only males, which indicated that fertilization had not taken place. It therefore seems probable that some *D. isaea* genetic material has been added to the *D. intermedius* gene pool in the USA. How-

ever, *D. isaea* females appear to be reproductively isolated from *D. intermedius*, so their disappearance may have resulted from competitive displacement with *D. intermedius*, or from mating (without fertilization) with *D. intermedius* males, which were far more abundant in the field than *D. isaea* males.

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