

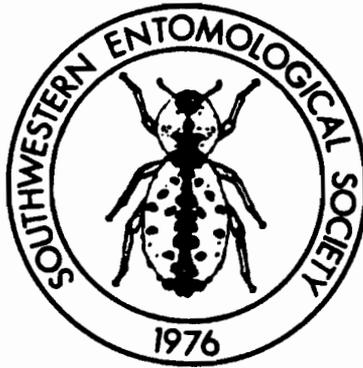
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RELEASE AND RECOVERY OF IMPORTED PARASITOIDS OF THE
RUSSIAN WHEAT APHID IN EASTERN COLORADON. C. Elliott, J. D. Burd, J. S. Armstrong¹, C. B. Walker², D. K. Reed, and F. B. Peairs³USDA, ARS, Plant Science and Water Conservation Research Laboratory
1301 N. Western St., Stillwater, Oklahoma 74075

ABSTRACT

The exotic hymenopterous parasitoids *Aphelinus asychis* Walker, *Aphelinus albipodus* Hayat and Fatima, *Aphelinus varipes* (Forester), *Diaeretiella rapae* M'Intosh, *Aphidius colemani* Viereck, *Aphidius matricariae* Haliday, and *Ephedrus plagiator* (Nees) were released at several sites in eastern Colorado from 1991 through 1993 in an attempt to establish the species in wheat agroecosystems for biological control of the Russian wheat aphid. Recovery of *A. asychis* and *A. albipodus* near Akron and *A. asychis* near Pritchett in 1994, one year after releases were made at the locations, indicates that exotic species had established populations. Recovery of *D. rapae* in relatively high numbers in 1994 near Akron where previous surveys had shown rare incidence of parasitism of Russian wheat aphids by this species suggests that an exotic strain of *D. rapae* may also have established. However, the increase in parasitism of Russian wheat aphids by *D. rapae* may reflect annual variation in parasitism rates by native *D. rapae* or adaptation by native *D. rapae* to the recently introduced host.

INTRODUCTION

In 1991, the USDA-ARS, Plant Science Research Laboratory began a cooperative program with USDA-APHIS, Colorado State Agricultural Experiment Station, and the Colorado Department of Agriculture to release parasitoids and predators that had been imported into the United States for control of the Russian wheat aphid (RWA), *Diuraphis noxia* (Mordvilko). The goal of the program was to establish exotic arthropod natural enemies in agricultural landscapes in Colorado to augment native biological control agents. Native natural enemies were apparently ineffective in controlling RWA populations (Wraight et al. 1993). The purpose of this paper is twofold: to report recoveries made in 1994 of exotic parasitoid species released in eastern Colorado from 1991 through 1993, and to document the exotic parasitoid releases so that future recoveries of exotic species can be traced to their release source.

¹ Colorado State University, Central Great Plains Research Station, P.O. Box K, Akron, CO 80720.

² Colorado State University, Southeastern Regional Research and Extension Program, 1001 S. Main St., Lamar, CO 81052.

³ Department of Entomology, Colorado State University, Fort Collins, CO 80523.

MATERIALS AND METHODS

Methods of parasitoid importation, quarantine, and shipment for field release are detailed in Michels and Whitaker-Deerberg (1993) and will not be repeated here. Field releases of parasitoids each year were conducted in spring (April-June) by one of two methods. By the first method (designated open-field releases), parasitized aphids (mummies) were released into RWA-infested fields according to procedures detailed in the USDA-APHIS Aphid Biological Control Project Manual (Harabin et al. 1990). The second method involved releasing mummies into field cages (designated caged releases). Field cages were constructed from saran screen material (52 strands per inch for cages holding aphelinids; 32 strands per inch for cages holding aphidiids). Cages were shaped like "pup-tents" and had dimensions of 1.8 m by 2.5 m by 0.6 m (width by length by height) in 1991 and 1.8 m by 5.0 m by 0.6 m in 1992 and 1993. The long axis of each cage was positioned in the field parallel to the rows of wheat. In 1991 four cages were used at a site for each species released. Four planter boxes (0.1 m by 0.3 by 0.1 m) in which densely planted wheat seedlings were growing were placed in each cage. The wheat in the boxes was heavily infested with RWA, a portion of which were parasitized. Approximately 2,000 parasitized RWA were placed in each cage. Wheat plants infested with unparasitized RWA from two additional planter boxes were cut and scattered within the area covered by each cage. Cages were closed by staking the edges and covering them with soil. In 1992 and 1993 two cages were placed at a site for each parasitoid species released. From 2,000 to 4,000 parasitoid mummies of a particular species were placed in each cage along with 8-10 planter boxes of wheat heavily infested with RWA.

Cages were removed after 2-3 weeks to allow parasitoids to disperse. Upon removal of cages, a sample of 10 tillers was taken from within each cage in order to estimate the number of RWA per tiller (A) and the number of live mummies per tiller (M). The number of tillers per 20 cm of row (T) was counted at two locations within each cage. A subsample of 200 RWA from within each cage was placed on a caged plant growing in the greenhouse for 7 days, at which time the number of mummies that formed was determined and expressed as a fraction (P) of the 200 RWA originally placed on the plant. The number of parasitoids released from a cage was then estimated as follows:

$$\text{No. Parasitoids} = (M + P \cdot A) \cdot T \cdot F,$$

where F is the number of 20-cm lengths of row enclosed by the cage.

Parasitoid releases were made at four geographically separated sites in Baca Co. (1.5 km southwest of Walsh; 4.5 km north of Walsh; 12 km southwest of Pritchett; and 21 km southwest of Pritchett), one site in Prowers Co. (17 km south of Lamar), one site in Washington Co. (6 km east of Akron), and one site in Larimer Co. (7.5 km north of Fort Collins). Single releases were made at the Prowers Co. site in 1991 and 1993, while two releases were made there in 1992.

Recovery surveys were made in the spring of 1994 at two 1993 release sites: one in Baca Co. (12 km southwest of Pritchett) and a second in Washington Co. Recovery surveys at the Baca Co. site were conducted in a wheat field approximately 0.4 km from the field in which releases had been conducted in 1993 by collecting 150 RWA-infested tillers at approximately weekly intervals from 15 April to 10 June 1994. Additionally, 10 RWA-infested plants were stationed in the field each week from 15 April to 10 June 1994. After 1 week the plants were collected and transported to the laboratory where they were held for 1 week to allow any parasitized aphids to mummify. Mummified aphids were collected and reared to adulthood. Recovery surveys at the Washington Co. site were accomplished by collecting 1,500 RWA-infested tillers on 9 May 1994 and 3,300 infested tillers on 23 May 1994 from a field planted adjacent to the field in which releases had been made in 1993. Adult parasitoids were reared

from mummies collected from the samples. Suspected exotic specimens were forwarded to the USDA-APHIS Biological Control Laboratory, Niles, MI, where they were tentatively identified to species and forwarded to the USDA-ARS Systematics Laboratory, Beltsville, MD, for confirmation of species identification.

RESULTS AND DISCUSSION

Six species of exotic hymenopterous parasitoids were released in eastern Colorado from 1991 through 1993: *Aphelinus asychis* Walker, *Aphelinus albipodus* Hayat and Fatima, *Aphelinus varipes* (Forester), *Diaeretiella rapae* M'Intosh, *Aphidius colemani* Viereck, *Aphidius matricariae* Haliday, and *Ephedrus plagiator* (Nees). Relevant information on exotic parasitoid releases is summarized in Table 1, including the county where each release was made, the country from which the parasitoids originated, the year they were collected, and the number of parasitoids released. The majority of parasitoids were released at sites in Baca and Prowers Counties. Averaged over the 3 years of releases, parasitoid numbers in cages increased approximately eight times compared with numbers initially placed in cages during the 2-3 weeks they were caged. Three species, *A. asychis*, *D. rapae*, and *A. albipodus*, accounted for the majority of parasitoids released in terms of total numbers and number of release sites, while only small numbers of *A. matricariae* and *E. plagiator* were released, each at a single site in only 1 year (Table 1). Approximately 1.6 million exotic parasitoids were released during the 3 years.

Specimens of two exotic species, *A. asychis* and *A. albipodus*, were recovered from infested tiller samples from the Washington Co. release site, and *A. asychis* was recovered from the Baca Co. release site 12 km southwest of Pritchett (Table 2). Extensive sampling was conducted during the spring of 1994 at three sites in Baca Co. geographically distant (>10 km) from our release sites; no exotic parasitoids were recovered in surveys of non-release sites.

Aphelinus asychis was released in nearby Oklahoma for greenbug biological control in 1970 (Jackson et al. 1971). To the best of our knowledge, *A. albipodus* was not released in the United States prior to initiation of the RWA classical biological control program. Neither *A. asychis* nor any other exotic species released during the greenbug biological control project were recovered in Texas from surveys of parasitoids of cereal aphids conducted since 1970 (Michels and Whitaker-Deerberg 1993). Published surveys of cereal aphid parasitoids conducted in small grain fields in Colorado prior to 1994 also failed to yield exotic species (Meyer and Peairs 1989, Wraight et al. 1993). Furthermore, none of the species released by us, except *D. rapae*, were observed in pre-release surveys made in small grain fields in eastern Colorado during 1991, 1992, and 1993, which involved inspection of several thousand cereal aphid-infested tillers (NCE unpublished data). Although *A. asychis* and *A. albipodus* were released at other sites in Colorado by us, and others, during the RWA classical biological control program, they were not released in Washington Co. prior to, or after, our release in 1993. Evidence from Texas, where *A. asychis* and *A. albipodus* were established in 1992 from 1990 releases indicates that the rate of range expansion by these species from initial establishment sites is slow (G. J. Michels, personal communication). Thus, the most probable source of the two exotic aphelinid species recovered at the two sites was from local populations that established from 1993 releases.

Several adult *D. rapae* were collected at the Akron and Pritchett release sites in 1994 (Table 2). *Diaeretiella rapae* is an endemic parasitoid of several pest aphid species, including the RWA, in a variety of agroecosystems (Mackauer and Stary 1967). The parasitoid was imported into the United States from several locations in Europe and Asia for RWA biological

TABLE 1. Numbers of Russian Wheat Aphid Parasitoids Released in Eastern Colorado from 1991 through 1993. Releases Were Made in Wheat Fields from Within Field Cages or Directly into the Open Field.

Release Type /County	Release Date(s)	Species	Year Collected	Country of Origin	Number Released
CAGED					
Prowers	5/21/91	<i>Aphidius matricariae</i>	1990	Turkey	7,900
		<i>Aphelinus asychis</i>	1990	Chile	4,600
		<i>Aphidius colemani</i>	1990	Argentina	16,900
Prowers	5/14, 5/28/92	<i>Aphelinus albipodus</i>	1991	Kazakhstan	76,000
		<i>Aphelinus asychis</i>	1991	Pakistan	79,700
		<i>Diaeretiella rapae</i>	1990, 1991	Iran, Kazakhstan	184,600
Prowers	6/26/92	<i>Aphelinus albipodus</i>	1991	Kazakhstan	1,200
		<i>Aphelinus asychis</i>	1991, 1992	Pakistan, Morocco	10,200
		<i>Diaeretiella rapae</i>	1991	Kazakhstan	1,200
Baca	5/2/93	<i>Aphelinus albipodus</i>	1992	China	39,700
		<i>Aphelinus varipes</i>	1992	Caucasus	20,000
		<i>Aphelinus asychis</i>	1992	China, Morocco	117,100
		<i>Diaeretiella rapae</i>	1992	Caucasus, China	52,000
Prowers	5/7/93	<i>Aphelinus albipodus</i>	1992	China	6,700
		<i>Aphelinus varipes</i>	1992	Caucasus	8,000
		<i>Aphelinus asychis</i>	1992	China, Morocco	30,400
		<i>Diaeretiella rapae</i>	1992	China, Caucasus	73,400
		<i>Aphelinus albipodus</i>	1992	China	27,400
Washington	5/11/93	<i>Aphelinus varipes</i>	1992	Caucasus	40,700
		<i>Aphelinus asychis</i>	1992	China, Morocco	127,500
		<i>Diaeretiella rapae</i>	1992	China, Caucasus	19,000
		<i>Aphelinus albipodus</i>	1992	China	7,200
Larimer	5/14/93	<i>Aphelinus varipes</i>	1992	Caucasus	29,100
		<i>Aphelinus asychis</i>	1992	China, Morocco	64,400
		<i>Diaeretiella rapae</i>	1992	China, Caucasus	98,800
		<i>Aphidius colemani</i>	1991	Argentina	236,600
OPEN FIELD					
Baca	4/15, 4/22, 5/13, 6/11/93	<i>Aphelinus albipodus</i>	1991, 1992	Several	71,300
		<i>Aphelinus asychis</i>	1991, 1992	Several	36,650
		<i>Diaeretiella rapae</i>	1991, 1992	Several	6,525
		<i>Ephedrus plagiator</i>	1992	China	1,000
		<i>Aphelinus varipes</i>	1992	Caucasus	3,900

control. It is currently not possible to distinguish native from exotic *D. rapae*. Surveys made prior to release of exotic *D. rapae* detected low incidence of parasitism of the RWA by this species (Meyer and Peairs 1989, Wraight et al. 1993). Although we conducted extensive releases of exotic *D. rapae* in eastern Colorado and recovered *D. rapae* in surveys of release sites, it is not possible to determine whether the *D. rapae* collected are native or exotic. The

TABLE 2. Numbers of Parasitoids Recovered During 1994 from RWA-Infested Tiller Samples Collected from Two 1993 Release Sites

Release Site	Species	No. Recovered
Washington County (6 km east of Akron)	<i>Aphelinus asychis</i>	4
	<i>Aphelinus albipodus</i>	57
	<i>Diaeretiella rapae</i>	10
Baca County (12 km southwest of Pritchett)	<i>Aphelinus asychis</i>	3
	<i>Aphelinus albipodus</i>	0
	<i>Diaeretiella rapae</i>	12

relatively high incidence of recovery of *D. rapae* at the two release sites suggests that an exotic strain of this species may have established. Monitoring populations in future years may provide circumstantial evidence that exotic *D. rapae* has established. A marked increase in the incidence of parasitism of RWA by *D. rapae* in future years at release sites might be expected if a genotype of *D. rapae* better adapted at exploiting RWA populations has established at the site.

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