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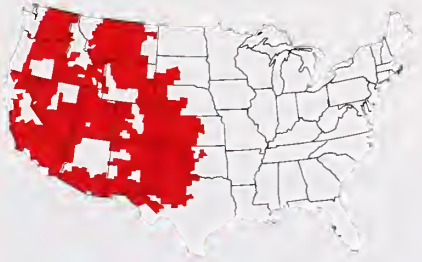
Biological Control of the Russian Wheat Aphid

Cover photo: Parasitic wasps such as *Diaeretiella rapae* keep Russian wheat aphid populations from reaching damaging levels on small grains and many other crops. (Photo courtesy of Jack Kelly Clark, University of California Statewide IPM Project.)

Populations of most native insects are held in check by parasites, predators, and disease organisms. But exotic pests that manage to enter the United States, like the Russian wheat aphid, do not have locally established natural enemies. When the population of such pests builds to the point where they are causing economic damage, farmers often turn to the use of chemical insecticides. Since 1962, the U.S. Department of Agriculture (USDA) has been working to develop *biological* control techniques to suppress pests. These techniques can reduce farmers' dependency on insecticides.

In biological control, natural enemies are used to reduce pest populations to subeconomic levels—not eradicate pests altogether. Biological control has been successful against many insect pests, including aphids, in North America for over a century. USDA's Animal and Plant Health Inspection Service (APHIS) has been cooperatively involved with biological control projects for many years. In fact, when the Russian wheat aphid first appeared in the United States in 1986, APHIS' biological control program was already working on a project to release natural enemies against other aphid pests. This project formed the basis for becoming involved in a more intense, cooperative campaign directed specifically against the Russian wheat aphid.



Distribution map of Russian wheat aphid in the United States, as of December 1992. (Data are derived from the National Agricultural Pest Information System [NAPIS].)

Origin of the Problem

The Russian wheat aphid—*Diuraphis noxia* (Mordvilko)—originated in south-central Russia and is common in adjacent countries in Europe, northern Africa, the Middle East, and Asia. Perhaps as a result of expanded international trade in grains during recent decades, this insect has been carried into other countries, including South Africa and Chile. In North America, the Russian wheat aphid was first found in the early 1980's just north of Mexico City. From this initial infestation, it spread northward and reached Texas in 1986. By 1990, the Russian wheat aphid was found in 16 Western States and 3 Canadian Provinces, but it has not significantly expanded its North American distribution since then.

Characteristics of the Pest

Aphids—sometimes called plant lice—are small, soft-bodied insects that feed on plants by sucking their juices. The Russian wheat aphid is pale green and usually covered with powdery white wax. Most individuals are wingless, but large numbers of winged forms develop when grain plants mature. Although aphids are weak fliers, the wind carries them long distances.

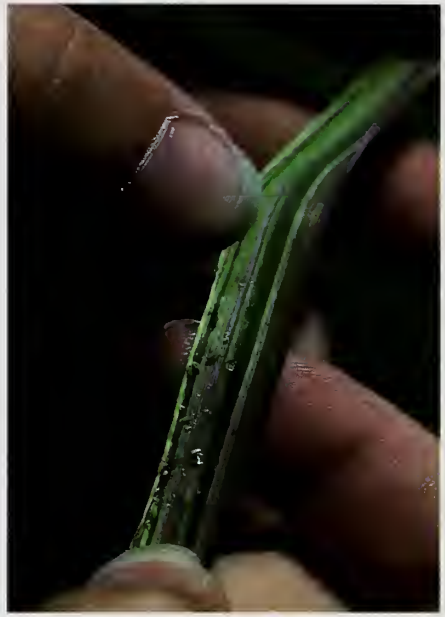
Three characteristics distinguish the Russian wheat aphid from other aphids that feed on small grains:

- Stubby, hard-to-see cornicles (twin projections near the tip of the abdomen);
- An apparent double tail, especially when viewed from the side (no other grain aphids have this);
- Short antennae that are less than half the length of the body.

Nature and Cost of the Problem

Like other aphids, the Russian wheat aphid feeds on plants by inserting its mouthparts into vascular tissues to tap the flow of nutrient-rich sap. By itself, such interference with a plant's nutrition can reduce yields. But while it feeds, the Russian wheat aphid also injects a toxin that causes leaves to discolor and roll into strawlike tubes that enclose the pests. Heavily infested grain fields may have large areas of stunted and dying plants.

Russian wheat aphid adults and nymphs feeding on a grain leaf.



Russian wheat aphid colony on damaged wheat leaf. At lower left is a brown parasitized aphid ("mummy").

The Russian wheat aphid prefers barley and wheat but also attacks oats. In some infested fields, grain yields have dropped by as much as 70 percent. The grain from infested plants may also be of lower nutritional quality.

The presence of Russian wheat aphids in a field is usually revealed by damage to host plants.

- Infested leaves have white to reddish-purple streaks along the veins.
- The margins of infested leaves roll up into a tube. Rolled leaves may become so disfigured that they take on a corkscrew appearance.
- Infested plants appear stunted and produce fewer tillers, which often become prostrate instead of remaining upright.

Russian wheat aphid infestations usually originate on basal leaves of tillers, but as tillers elongate, aphids move upward to younger leaves. Moderately infested plants produce smaller grains and fewer grains per head. When developing grain heads get trapped inside infested terminal leaves, the heads cannot reach their full extension. Heavily infested plants may die.

When a field is initially invaded by Russian wheat aphid, widely spaced patches of plants with characteristic symptoms appear. As the infestation progresses, these patches expand and coalesce, eventually resulting in large areas of dead or dying plants.

Since the Russian wheat aphid came to North America, grain farmers

A wheat plant showing Russian wheat aphid damage.
(Photo courtesy of Texas A & M University.)

have controlled it primarily by the application of insecticides. However, with the aphids protected inside rolled-up leaves of the host plant, insecticidal control is difficult and expensive. Also, there is great concern that the initiation of chemical control programs in expansive acreages of small grains may aggravate existing environmental problems or create new ones.

From 1987 through the 1988–89 growing season, crop losses attributable to Russian wheat aphid infestations in the Western United States totaled

This dryland wheat field in New Mexico suffered significant damage from Russian wheat aphid. (APHIS photo by Bob Flanders.)

Wheat leaves in a plant attacked by the Russian wheat aphid tend to roll, trapping the developing grain head. When the grain head cannot mature properly, yield and quality are adversely affected.

approximately $221 million, and an additional $55 million was expended for control. During the 1989–90 growing season, infestations were not as widespread as in previous years, but yield losses still totaled over $33 million. Control costs amounted to just over $15 million, and the pest exerted an estimated indirect impact on the community of over $44 million. These monetary losses, as well as possible environmental and social costs, may increase and will continue to accumulate if more effective and environmentally appropriate control measures are not developed.

In the native home of the Russian wheat aphid, several species of parasites, predators, and pathogens attack it. These natural enemies probably are the primary reason why high densities of the pest rarely develop in these regions. In newly invaded regions, where no effective natural enemies exist, the Russian wheat aphid quickly becomes a major pest.

The goal of biological control efforts against the Russian wheat aphid in North America is to locate, import, and establish effective natural enemies. When successful, this approach will safely and permanently reduce Russian wheat aphid densities below economically significant levels.

Initial Biological Control Activities

When the Russian wheat aphid first invaded Texas, the APHIS Biological Control Program was already releasing in the West the sevenspotted lady beetle *(Coccinella septempunctata* L.), a predator of several aphid pests. In Europe and Asia, this lady beetle is a common predator of the Russian wheat

The larva of a predaceous fly *(Leucopis* sp.) feeding on Russian wheat aphid.

Parasitic wasp *(Aphidius* sp.) ovipositing in a Russian wheat aphid.

Adult lady beetle *(Cycloneda ancoralis* sp.) feeding on a grain aphid. (Photo courtesy of Max Badgley.)

aphid. During 1988 and 1989, approximately 300,000 adult lady beetles were released at several sites in California, Nevada, Oregon, and Washington. Surveys during 1990 and 1991 indicated that the sevenspotted lady beetle had become established at most of the release sites and was feeding and reproducing on various aphids, including the Russian wheat aphid. It will take several years to evaluate the impact of this predator on the Russian wheat aphid, but observations now suggest that other natural enemies are required to achieve more uniform control.

In 1987, APHIS began to release two other European lady beetles *(Hippodamia variegata* [Goeze] and *Propylea quatuordecimpunctata* [L.]) that had also become established in northeastern North America. These species were initially released against various aphids to obtain the beetles' establishment throughout North America. Like the sevenspotted lady beetle, these predators are commonly associated with the Russian wheat

Releasing lady beetle adults in a field of Russian wheat aphid-infested wheat. (APHIS photo by Bob Flanders.)

aphid in Europe. When APHIS narrowed its focus to the Russian wheat aphid in 1988, these species consequently became an integral part of the project.

Putting Russian wheat aphid parasites into nylon mesh cages to help guarantee initial establishment of parasites in the field.

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Sorting natural enemies by aspiration to evaluate their establishment and impact in the field.

Foreign Exploration for Natural Enemies

Scientists from USDA's Agricultural Research Service (ARS), universities, State agricultural experiment stations, and cooperating foreign organizations began exploring various countries in 1988 to collect natural enemies of Russian wheat aphid for importation to North America. Most explorations have been in regions native to the Russian wheat aphid, including China, France, Greece, Jordan, Pakistan, Spain, Syria, Turkey, and several states of the former Soviet Union (Moldavia, Ukraine, Kazakhstan, Kirghizia, etc.).

Natural enemies of Russian wheat aphid collected in foreign countries are shipped to federally authorized quarantine facilities prior to their release in North American fields. In quarantine, the natural enemies are identified and reared for at least one generation to eliminate all undesirable organisms.

Immediately following clearance from quarantine, small numbers of most natural enemies are released at a few sites in some States. These initial releases are usually performed by university, extension, ARS, or State department of agriculture personnel. As initial releases are performed, colonies of the beneficial organisms are shipped to an APHIS laboratory, where cultures are initiated and techniques are developed to rear the beneficial insects in large numbers. APHIS personnel manage the mass-rearing process and coordinate extensive releases in infested States. Individuals from universities, ARS, and State departments of agriculture and other involved groups are relied upon to perform laboratory and field research that may help implement and evaluate the APHIS program.

An APHIS laboratory technician counts laboratory-reared natural enemies for subsequent release.

Releases of Exotic Natural Enemies in the United States

From 1987 through 1992, APHIS reared 23 species and 76 geographic strains of parasites and predators for release against the Russian wheat aphid in the United States (table 1). During this time, over 5.4 million parasites and predators were released into 151 sites in 26 States by APHIS personnel and ARS, university, extension, and State cooperators.

Initial releases of exotic natural enemies are undertaken to obtain their establishment, not necessarily to control a specific pest immediately. These initial releases are consequently limited to a few fields or areas in each infested State. When one or several effective natural enemies become established, then a modified release strategy is developed to redistribute the species throughout each infested State.

Although some releases of Russian wheat aphid predators are being made into commercial fields of wheat or barley, most releases are made into fallow fields in the Conservation Reserve Program (CRP) that contain some small grains or grasses susceptible to Russian wheat aphid. CRP fields are preferred

Table 1—Russian wheat aphid natural enemies released by APHIS' Aphid Biological Control Project from 1987 through 1992

Coleoptera: Coccinellidae

Adalia bipunctata—Uzbekistan (Tashkent)

Coccinella septempunctata—Canada (Quebec); France (Alpes–Maritemes); Syria (Khafsa); Moldavia (Kishinev); Ukraine (the Crimea); United States (Delaware, Georgia, Indiana, Maryland, Michigan); Uzbekistan (Chaek)

Coccinella transversoguttata biinterrupta Mader—Kirghizia (Tien-Shan)

Coleomegilla quadrifasciata (Schoenherr)—Argentina (Santa Fe)

Cycloneda ancoralis (Germar)—Argentina (Santa Fe)

Eriopis connexa (Germar)—Argentina (Santa Fe)

Hippodamia tredecimpunctata (L.)—Kirghizia (Tien-Shan); Moldavia (Kishinev); Ukraine (the Crimea)

Hippodamia variegata (Goeze)—Canada (Quebec); Chile (Santiago); France (Alpes–Maritemes, Drome); Kazakhstan (Alma-Alta); Kirghizia (Tien-Shan); Moldavia (Kishinev); Morocco (Marrakech)

Oenopia conglobata (L.)—Uzbekistan (Tashkent)

Propylea quatuordecimpunctata (L.)—Canada (Quebec); France (Drome); Kazakhstan (Dmitrievka); Kirghizia (Chaek); Moldavia (Kishinev); Turkey (Beypazari)

Scymnus frontalis Fabricius—Turkey (Beypazari)

Semiadalia undecimnotata (Schneider)—Ukraine (the Crimea)

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Table 1—Russian wheat aphid natural enemies released by APHIS' Aphid Biological Control Project from 1987 through 1992 (Continued)

Diptera: Chamaemyiidae

Leucopis ninae Tanasijtshuk—China (Wuqia, Yining); Iran (Dashtak); Pakistan (Parachinar); Uzbekistan (Tashkent); Yugoslavia

Diptera: Syrphidae

Eupeodes nuba—Iran (Fars); Kazakhstan (Dmitrievka)

Hymenoptera: Braconidae (Aphidiinae)

Aphidius colemani Viereck—Jordan (Disi); Pakistan (Parachinar)

Aphidius matricariae Haliday—Iraq (Nineva); Moldavia (Kishinev); Pakistan (NWFP); Turkey (Konya)

Aphidius picipes (Nees)—Czechoslovakia

Aphidius rhopalosiphi DeStefani—Turkey (Izmir)

Diaeretiella rapae (M'Intosh)—China (Wuqia); France (Antibes); Iran (Ehglid, Fars); Jordan (Disi); Kazakhstan (Dmitrievka); Kirghizia (Iachmen); Morocco (Marrakech); Pakistan (Parachinar); Syria (Qatara); Uzbekistan (Tashkent)

Ephedrus plagiator (Nees)—Turkey (Beypazari)

Praon gallicum Stary—France (Drome)

Hymenoptera: Encyrtidae

Aphelinus asychis Walker—Chile (Chillan); France (Antibes); Kazakhstan (Dmitrievka); Pakistan (Parachinar)

Aphelinus sp. nr. *varipes* (Foerster)—China (Alta, Yining); Iran (Fars); Kazakhstan (Dmitrievka, Kustanay); North Caucasus (Budennovsk, Pyatigorsk, Stavropol); Pakistan (Parachinar); Turkey (Beypazari); Uzbekistan (Tashkent)

Aphelinus varipes (Foerster)—Turkey (Beypazari)

for several reasons, including their relative permanency, tolerance to high densities of Russian wheat aphid, and low likelihood of receiving insecticide applications. The ideal situation is where a CRP field being used for release is surrounded by commercial small-grain fields infested with the Russian wheat aphid.

During the spring and early summer of each year, fields where Russian wheat aphid predators were released are extensively sampled. Information from these samples is used to monitor the presence and activities of native and exotic natural enemies in the fields. Results of these sampling efforts determine whether or not a previously released species has become established and what impact it is having on the density of Russian wheat aphids. Information from all States and fields will be used to evaluate the biologic and economic impacts of the exotic species objectively as they become established under different climatic, geographic, and cultural conditions. Analyses of these data will also help justify and plan subsequent efforts to redistribute the most effective natural enemies more widely.

Natural enemies being imported to North America against the Russian wheat aphid may also attack other aphids, such as greenbug and English grain aphid, in small grains and other crops. Consequently, some APHIS releases are being made into other crops in States not infested by the Russian wheat aphid. Some of the natural enemies being released may control aphid pests other than or in addition to Russian wheat aphid.

Benefits on the Farm

Although biological control appears to have tremendous potential against the Russian wheat aphid, it will take several years to establish and distribute effective natural enemies and to obtain a reliable level of crop protection. During this time, growers of small grains must remain patient and avoid any practices that could adversely affect either the exotic natural enemies that have been released or native natural enemies.

Widespread and repeated use of insecticides to control the Russian wheat aphid is the greatest hindrance to implementing biological control successfully. Most insecticides are more toxic to natural enemies than to aphids. Where natural enemies have been released, applications of insecticides should be avoided as much as possible, especially in release fields and adjacent areas. Even in fields or areas where natural enemies have not been released, growers should make sure that an economic problem exists before they apply insecticides. The existence of one severely infested field does not necessarily indicate that surrounding fields are similarly infested. All fields should be examined before an insecticide is applied.

Farmers should contact their local agricultural extension office to find out how to manage Russian wheat aphid effectively in their small-grain fields. Extension personnel will supply instructions on how to sample for aphids and how to determine if an insecticide application is necessary. Information on alternative control measures like the use of resistant plant varieties and cultural control practices should also be available.

Further information on the potential and status of natural enemy releases in a State or area can be obtained from the local agricultural extension agent, county agricultural commissioner, State department of agriculture, or the nearest USDA-APHIS office.

Outlook

Biological control may not eradicate damaging pests instantly, but natural enemies can offer a chance for permanent relief without requiring growers to spend money. If growers, the grain industry, universities, and Federal and State governments continue to work together, they can achieve a level of biological control that will keep the Russian wheat aphid from inflicting significant economic damage. The history of other successful biological control projects in the United States can give farmers confidence that this technology does work and can control the Russian wheat aphid.

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Unless otherwise credited, all pictures in this brochure were taken by APHIS photographer Laurie Smith.