

Coleophora spp. as Biological Control Agents Against Russian Thistle¹

by
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ABSTRACT

The moth, *Coleophora parthenica* Meyrick, was introduced into the U. S. from Egypt and Pakistan after biology and preliminary testing had been conducted in the countries of origin under PL 480 programs. Further host specificity testing was carried out at the USDA facility at Albany, California, and the moth has since been released at several sites in the western states. As a result, populations have been established at some field sites, primarily in California, and the insect is now being redistributed to other areas that are infested by Russian thistle.

Since larvae of the moth feed inside the stems of Russian thistle, a plant attacked by a large population essentially becomes a hollow shell. For example, at one site in 1975, larval populations averaged 15/m in the primary and secondary stems, and 88% of the length of these stems was hollow. Such feeding caused outright death of some plants and severe stunting and reduced seed production in others. *Coleophora parthenica* is multivoltine, and the number of generations produced varied with temperature and the length of growing season.

A second moth, *C. klimeschiella* Toll, whose larvae feed on the leaves of Russian thistle, has also been tested and is now ready for field release.

Russian thistle, *Salsola iberica* Sennen & Pau (= *S. pestifer* A. Nels.), is a weedy annual plant distributed widely in the United States. The plant is a member of the family Chenopodiaceae, is a native to Central Asia, and was originally introduced into the United States in 1873 as a contami-

nant of flax seed that was planted near Scotland, South Dakota (Robbins *et al.*, 1951). Since then it has spread over most of the central and western states and is now spreading along the eastern and southern coasts (Reed 1970). Russian thistle infests range and semi-arid pasture lands as well as cropland, railroad and highway right-of-ways, and vacant agricultural, residential, and industrial areas. At maturity, the plant fractures at the base and rolls in the wind (becoming a tumbleweed) so it piles up against fences and buildings and clogs culverts and waterways. In the western states, it also is the primary alternate host of the beef leaphopper, *Circulifer tenellus* (Baker), which is the vector of the "curly top" virus of such crops as sugar beets, tomatoes, and cucurbits (Lawson and Pie-meisel 1943).

A survey for insects associated with Russian thistle was made by Andres⁴ in south central Russia during the summer of 1965. He found a number of apparently host specific insects associated with annual species of *Salsola*, but we were not able to study many of them due to the inaccessibility of the location. However, in PL 480 programs set up to study control of Russian thistle in Pakistan and Egypt in the late 1960's, many of the same insects were found, particularly in northern Pakistan (Baloch and Mushtaque 1971). Also, Goeden (1973) made an insect survey of Russian thistle in Turkey during 1970 and found a number of promising insects in that country. Entomologists from Pakistan and Egypt therefore began simultaneous testing programs of several of these insect species as PL 480 projects. The test results, unfortunately, showed that many of the promising defoliators would feed on economically important chenopods (such as beets and spinach) under forced feeding test conditions, even though they have never been recorded from these plants in nature. Therefore, some promising species had to be rejected, but probably should be reevaluated with some different types of test procedures. In order to circumvent the problem with economic chenopods, host specific insects with specialized life

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⁴ L. A. Andres. 1965. Unpublished notes, USDA, ARS, Albany, CA.

histories were given priority in the program.

Coleophora parthenica

One such insect that is host-specific to Russian thistle is *Coleophora parthenica* Meyrick, a microlepidopteran of the family Coleophoridae whose larvae bore inside the stems of the plant. *Coleophora parthenica* was originally described from Algeria, but it apparently ranges across North Africa, through the Middle East into Afghanistan and Pakistan and northward into Russia. Preliminary tests in Pakistan (Ghani 1970) and in Egypt (Hafez 1970) indicated the insect is host-specific to *Salsola* and *Halogeton glomeratus* (M. Bieb.) C. A. Mey., also an introduced annual chenopod, that has become a serious weed pest of dry western rangeland.

Life History.—The moths of *C. parthenica* emerge during late May-early June and lay their eggs singly on leaves near the terminal ends of Russian thistle stems. The new larvae bore through the bottom of the eggs directly into the leaves. After they feed in the leaves for a few days, they move into the stems. Each larva can hollow out ca. 15 cm of stem during its development. At maturity, the larva cuts a transparent exit window in the stem leaving only the epidermis intact. Pupation then occurs inside the hollow stems, and the moths emerge through the exit windows. The insect is multivoltine, the number of generations produced depending on temperature. Mature larvae of the last generation diapause and overwinter inside the dead, dry Russian thistle stems; pupation occurs the following spring.

Coleophora parthenica was introduced into the USDA quarantine at Albany, California, in 1971, and an extensive host specificity testing program was carried out in 1971-72 (Hawkes and Mayfield, in press) in which 27 plant species were exposed to both oviposition and larval feeding. These plants included all the crop species in the family Chenopodiaceae and beneficial browse species and common weeds in the same family. In addition, several species of plants from closely related families and other common crop plants were tested. The *C. parthenica* females, like many species of microlepidoptera held in confinement, laid some eggs on non-host plants and on non-living objects within the test cages, and the oviposition tests were generally inconclusive, except that the moths seemed to prefer to oviposit on plants with leaves morphologically similar to those of Russian thistle, i.e., long and cylindrical. The larvae, in contrast, are highly host-specific and were not able to utilize

any test plants except *Salsola iberica*. Some minor feeding on non-host plants did occur by first-instar larvae, but all died within a few days of emergence from the eggs.

Coleophora parthenica occurs over an extensive geographic range from north Africa into south central Russia. Thus one might wonder if we are dealing with the "same insect" throughout the entire range. Cross mating studies were conducted to get an indication of any variation between populations from different portions of the range. One series of tests was conducted with Pakistan males crossed with Egyptian females (and vice versa). The test was very limited in size because of a lack of moths from the two countries at the same time; however, about half the females in each cross produced viable eggs, so some mating did occur. A second series of tests involved crosses between Pakistan males and Russian females (and vice versa). Here an adequate number of moths was available. Viable eggs were produced in all crosses, but there apparently are some sexual differences between the two populations: only about half as many eggs were laid in the crosses as in the controls (males X females from the same population). Also, egg viability was 80% or more for all crosses except the Russian male X Pakistan female test in which it was only 46%. Thus, there did not seem to be total sexual compatibility between the two populations, which pointed to biotype or strain differences.

Field Releases.—The first field releases of *C. parthenica* in the U. S. were made during the spring of 1973 (Hawkes *et al.* 1975) at several sites in the southern half of California and also one each in Idaho, Nevada, and Utah. Establishment occurred at some California sites and at the Nevada site. Since then we have concentrated on building up working field populations and establishing *C. parthenica* at more sites in California. During the spring of 1976 a shipment of overwintering larvae was made to Arizona for release in the Phoenix and Tucson areas.

The original field releases were made in large field cages measuring 2 m wide x 4 m long x 2 m high that were placed over actively growing Russian thistle plants. As many as 100 moths were released on the enclosed plants, and the insects were allowed to complete 1 or 2 generations before the cages were removed. Due to the tumbling action of the dead plants during windy periods, infested plants had to be confined during the winter season to avoid having them blown away.

Beginning in 1975, new releases have been made, primarily in the southern half of California, with insects from one well-established field site. Approximately one cubic meter of either green plant material containing mostly pupae or dry plant material containing overwintering larvae was used in the new releases. We now try to take advantage of natural geographic features such as ravines or some sort of protected depression for new field releases. Because dead Russian thistle plants do not tend to blow out of such areas during the winter, we can avoid fencing and confining the plants to keep the newly established population intact. Using these techniques it is relatively easy to establish new field colonies since as many as 500 to 1,000 insects may be contained in a cubic meter of moderately compressed plant material.

Populations and Plant Damage.—The rate of population buildup at a release site is dependent on the number of generations produced during the growing season, and this varies with length of growing season and summer temperatures. In the San Joaquin Valley of California, three generations are produced with spring moth emergence beginning as early as mid-May, and insect activity continuing through October. For example, at a site near Kettleman City, where the insect was released in 1974, the 1975 populations averaged 15 larvae/m of primary and secondary plant stems by October and 88% of the length of these stems was hollow. These were small plants averaging only about 30cm high. At another site near Indio where insects were also released in 1974, plants that averaged about 100 cm high contained 3 larvae/m of primary and secondary stem. At the Kettleman City site, the large populations of larvae caused death of some plants and severe stunting and reduced seed production in others. At the Indio site, the plants grew to be large, but the foliage in the center portions was dead and dried, and there was only a fringe of green foliage remaining around the outer circumference. Also, little seed was produced by plants at this site but it is uncertain whether this can be wholly attributed to *C. parthenica* damage. At least three generations per season are produced at the Indio site. At a third site, near Wadsworth, Nevada (typical for the Great Basin area of the western U. S.), only one generation per summer is produced. Due to the cooler spring and short-growing season much emergence occurs around July 1, and insect activity stops in early September. A release was made at this site in 1973, but in October 1975, only 1 larva/4 m

of plant stem could be found. Obviously such low populations are not causing any significant damage.

Russian thistle produces vegetative growth throughout the spring and summer and normally flowers and produces seed from mid-summer to early fall. The feeding of *C. parthenica* inside the plant stems apparently does not cause any acute damage to vital plant tissues. However, the plant appears to succumb gradually over the summer to massive chronic damage as it becomes a weakened hollow shell. Where *C. parthenica* has multiple generations, renewed pressure is placed on the plant with each successive generation of the insect that attacks the new terminal growth. With only one generation, populations probably cannot be attained that will cause the sustained chronic pressure, and the plant will outgrow the effects of the insect.

Coleophora klimeschiella

During the course of PL 480 studies in Pakistan in 1974, a second species *Coleophora klimeschiella* Toll, was found attacking *Salsola*. This was the first time that this insect was found in abundance and causing appreciable damage to its host plant in Pakistan (Ghani 1974).

Like *C. parthenica*, *C. klimeschiella* has a specialized life history which adds to its host specificity. The larvae are case-bearers and require leaves similar to those of *Salsola* from which to fashion their cases. The last-instar larvae overwinter inside the cases. Pupation takes place in the spring, and the moths emerge during late May and early June. The eggs are laid singly in the leaf axils; the newly emerging larvae feed under the leaf epidermis for ca. a week during which time they complete two instars. At the end of the second instar, the larvae emerge from the leaves and form cases; thus they are case-bearers for the remainder of the larval stage. Since the larvae are quite mobile and move the cases from one leaf to another, they destroy several leaves during development. This insect too has multiple generations, the number again depending on the length of the growing season and summer temperatures. Ghani (1974) thought that *C. klimeschiella* might be more effective as a biological control agent than *C. parthenica*. Goeden (1973) collected the same insect in Turkey, reported that its feeding activities complemented those of *C. parthenica*, and felt that it warranted further study.

Preliminary host specificity tests were conducted with *C. klimeschiella* in Pakistan during 1974. The

insect was further tested at Albany during 1975-76 and has now been approved for field release.

Hopefully the combination of *C. parthenica* feeding inside the stems and *C. klimeschiella* feeding on the leaves of Russian thistle will stress the plant to the point of control. *Coleophora klimeschiella* also appears to be better adapted to areas with shorter growing seasons and cooler summers. In the laboratory it can complete a generation much faster than *C. parthenica*, and should be able to mature at least two full generations per season in most areas of the western U. S.

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