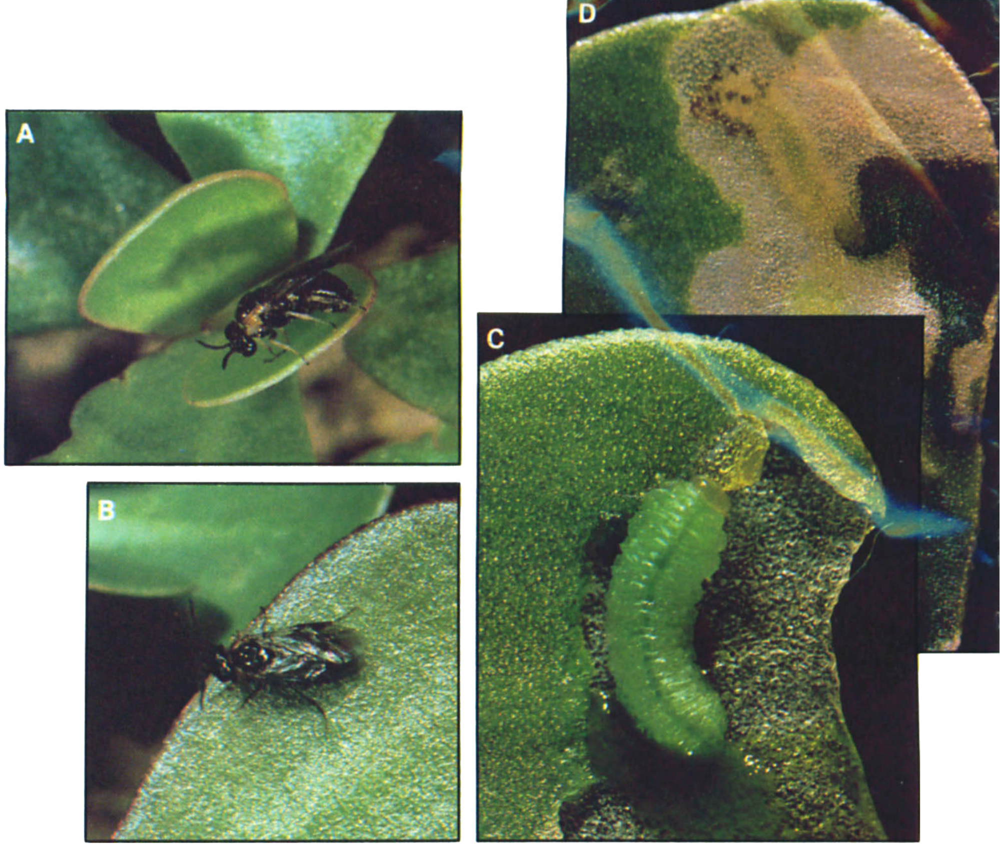
They stress the weeds, reducing their vigor and seed production.



Two insects offer potential biological control of

Stephen L. Clement □ Robert F. Norris

Since the arrival of the Spaniards during California's Mission Period from 1769 to 1824, man has introduced, either unwittingly or on purpose, exotic plants into California. Unfortunately, many of these plants have become some of our worst agricultural weeds. Like their counterparts on rangelands and in aquatic habitats, these plants usually arrive without their natural enemies; thus, they are often able to grow and spread unimpeded.

To try to correct this situation, biological control specialists conduct foreign exploration programs to find suitable natural enemies for importation. Sometimes, however, natural enemies accompany their weedy host plant to a new locality or they later reach it accidentally. For example, two insects that are natural enemies of common purslane, *Portulaca oleracea* L., a weedy annual in many crops, have been accidentally introduced into California, where they feed on this plant. The goal of the research reported here was to study the impact of these natural enemies on purslane growing in various crops.

Insect enemies of purslane

Entomologists have surmised that common purslane and the purslane sawfly, *Schizocerella pilicornis* (Holmgren), a natural enemy of this weed, both arrived in the eastern United States from Europe before 1800. Although it is not known when the sawfly arrived in California, common purslane was established in the state by 1860. Dr. D. Force, working in the U.S. Department of Agriculture Biological Control of Weeds Laboratory in Albany, California, during the early 1960s, was the first to document the presence of the sawfly in California. It was most abundant in the hot, interior areas of the state and was seldom found in cool, coastal regions.

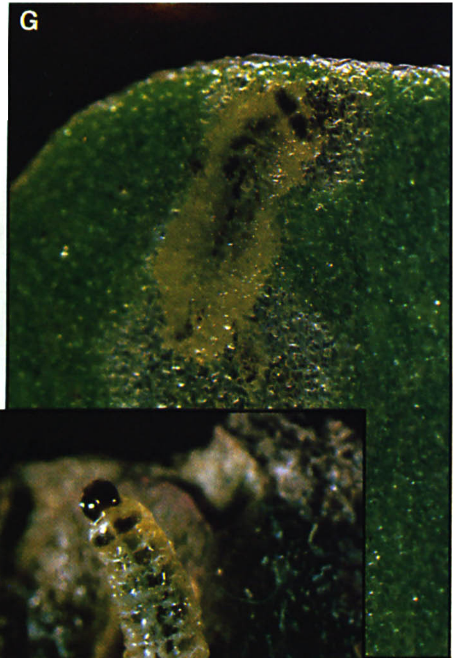
Another natural enemy of common purslane, the portulaca leafmining weevil, *Hypurus bertrandi* Perris, has spread without the intentional help of man from its home in the Mediterranean region to the United States, where it was first discovered in Hawaii in 1950. In California the first adult *H. bertrandi* was discovered near Davis in October 1980 by Professor W. Lange, University of California Department of Entomology, Davis. By late August 1981, we found the weevil in six counties (San Joaquin, Yolo, Colusa, Sutter, Glenn, and Butte) attacking purslane in such diverse cropping systems as peach and walnut orchards and tomato fields. Of the areas surveyed, the weevil was most abundant in the Student Experimental Farm at U.C., Davis.

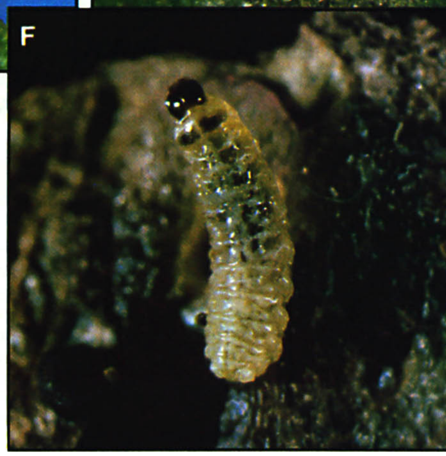
The general life cycle of the sawfly in California is fairly well known. Overwintering prepupae or pupae in the soil develop into adults in April or May, after which the insect completes several generations (number is unknown) on purslane until larvae develop into overwintering forms in September and October. From the literature, we also know that the larvae are miners only in the thick leaves of purslane; the adults do not feed.

Larvae of the weevil, like those of the sawfly, mine the leaves of purslane. Weevil adults damage leaves by actively feeding on the margins and epidermal surfaces. The adults also feed on stems and developing seed capsules, but such feeding does not appear to be as prevalent as leaf feeding. Common purslane is the only reported host plant of this weevil.

We do not yet know how the weevil overwinters in California, but we know the insect, like the sawfly, has the potential to become active at the onset of the purslane growing season. In a 1981 study site near a Yolo County tomato field, weevil larvae were detected as early as April 27. In the same vicinity, the first sawfly larvae of the season were collected on April 23. Unlike the sawfly, however, the weevil never did reach high population densities at this site in 1981.

We have evidence that, once the sawfly becomes active in the spring, it is capable of exploiting its host plant in the field. Data were obtained by counting the number of purslane leaves harboring sawfly eggs and larvae on one branch per plant from a series of plant samples. These plants, taken from the border of a Yolo County tomato field at three- to four-day intervals between April 27 and May 14, 1981, harbored eggs and larvae in 33 to 80 percent (range of average values during collection period) of their leaves. (Each collection was 10 plants randomly selected along a 50-meter transect.)





Purslane sawfly: (A) Adult female and (B) male (both 4X lifesize). (C) Larva (12X) has been pulled from its leaf mine (D), where it feeds between the epidermal tissues of purslane.

Portulaca leafmining weevil: (E) Adult male (12X). Adults of both sexes make feeding punctures in purslane leaves and seed capsules. (F) Larva (12X) has been pulled from its leaf mine (G). (Photos by Jack Kelly Clark)

common purslane

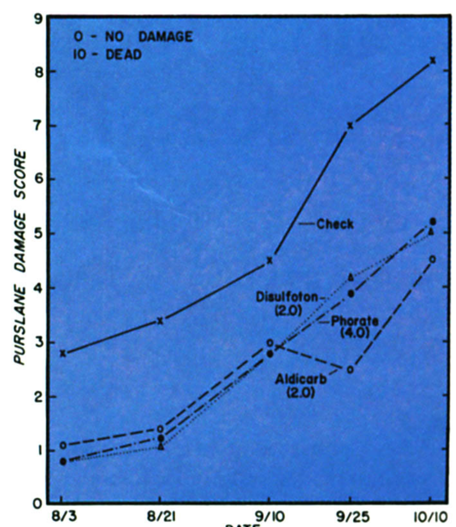
Purslane has been severely damaged by the sawfly and leafmining weevil.

Another series of plant samples, taken throughout the tomato field on May 7, 1981, showed that a high percentage of purslane leaves had been attacked by the sawfly. Average percentages of leaves (one branch per plant, 10 plants) harboring eggs and larvae ranged from 58.4 to 83.7 percent. (Each collection site was 645 square centimeters on a tomato bed.) Further, in a 14.9-square-meter plot at the U.C. Davis Farm, the sawfly started laying eggs on purslane leaves five days (on June 4, 1981) after the plants appeared above the soil surface.

In the laboratory the weevil and the sawfly completed their egg-adult cycles in 10 and 13 days, respectively, at 32.2° C (16 hours light). This suggests that each insect can complete its life cycle in a very short time in the hot, interior areas of California.

Biological control

In evaluating the effectiveness of the sawfly as a biological control agent of purslane, we used soil systemic insecticides to protect plants against attack by this insect, as well as other plant-feeding insects. At the U.C. Davis Farm in 1979, purslane was grown in a field, in which soil insecticides were applied to one series of plots; another series was left untreated. There were five replicates per treatment; each plot was four beds by 6.1 meters. Purslane plants from the untreated (check) plots suffered substantially more damage by the sawfly than did plants protected by the three insecticides (see graph). Fresh weight of plants protected by the insecticides was three to four times greater than that of plants not protected, and seed production was reduced 60 to 70 percent in



Visual estimate of insect damage (primarily sawfly) to purslane in untreated check (sawflies present) and treated plots (systemic insecticides, at rates in lb ai/acre shown in parentheses, incorporated into soil before sowing of purslane seed).

Purslane in untreated soil (foreground) has suffered much more sawfly damage than that in insecticide-treated soil (background).

unprotected plants. Moreover, preliminary results show that plants under sawfly attack produced seeds about 16 percent smaller with lower germination than protected plants.

The effect of the soil systemic insecticides in the 1979 study was to prohibit severe damage to purslane by the sawfly. A small-scale laboratory test conducted in 1981 showed that purslane leaves from plants grown in field plots treated with Aldicarb at 2 pounds active ingredient per acre were toxic to feeding adults of the leafmining weevil. Mortality was 100 percent when five weevils were allowed to feed for 48 hours on leaf clusters from insecticide-treated plants; no mortality occurred when five weevils fed on leaves from untreated plants. Illinois researchers have shown that carbaryl and malathion are highly toxic to the sawfly in the laboratory. These tests indicate that insecticides may interfere with the establishment of natural enemies on purslane in cropping systems where insecticide perturbations are commonplace.

Conclusion

Although it did not appear to us that the purslane sawfly or portulaca leafmining weevil actually killed any of the plants in the U.C. Davis plots, we are, nevertheless, encouraged that these insects seem capable of sufficiently stressing the weed to reduce its competitiveness and seed production. Further research is needed, however, to explore the possibility of integrating the two purslane-feeding insects into the weed management programs of crops where purslane is a problem. In this context we may be able to enhance the impact of the biological control agents by minimizing or altering cultural practices such as cultivation and pesticide use that adversely affect the survival of both insects. Also, as more data are generated on the reproductive biology and the predators and parasitoids of the sawfly and the weevil, as well as their competitive interactions, we should be able to better understand if the insects possess the attributes necessary for a good biological control agent.

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Mites: a primary food source for two predators in San Joaquin Valley cotton

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Most published predation studies have been concerned with the more common predators in the cotton field "food web"—the complex of pest and beneficial insects—and assume that major pest species are the principal prey. We believe that in California cotton, and perhaps in most cotton-growing areas, predators feed on a complex of primary and secondary pests, such as aphids, thrips, whiteflies, and mites. Indeed, the "secondary pests" may be an essential food source for the major predators.

Important elements of the cotton field food web are the predators the big-eyed bugs, *Geocoris* spp., and minute-pirate bug, *Orius tristicolor* White, as well as a complex of spider mites, *Tetranychus* spp., and *Thrips* spp. Secondary pest species need to be evaluated for their potential to serve as food sources for predacious arthropods. Under our scheme, these groups would be considered "secondary beneficial arthropods" because of their potential to provide food for beneficial arthropods, which may then increase in numbers and prey upon primary pests.

Our objective in this study was to sample cotton plants to determine the relative abundance of the various arthropods and to establish their role as primary food sources for major predacious arthropods.

Field trials

Our studies were conducted on 'Acala SJ-2' cotton at the U.S. Department of Agriculture Cotton Research Station, in California's San Joaquin Valley. Four schedules of nitrogen fertilization plus insecticide/acaricide application were used to create differences in numbers of arthropod predators and prey (see table). The experimental plots received weed control and irrigation treatments normal for the Shafter station. Each plot was 40 rows, or 133 feet (40 meters), wide and 200 feet (60 meters) long. The entire plot received a particular treatment.