

Predators of the two-spotted spider mite on strawberry

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There are many predators that can be integrated into a control program

Commercial strawberries, valued at \$270 million on 12,000 acres in California in 1983, are primarily grown as an annual crop on fumigated land. The plants are transplanted in beds mulched with clear polyethylene plastic. Most acreage now consists of winter plantings (transplanted in October/November) with drip irrigation.

Under these cultural conditions, the two-spotted spider mite, *Tetranychus urticae* Koch, is the most serious pest problem. During annual studies on strawberries in southern California from 1964 through 1980, the highest population that we recorded on a summer planting (transplanted late August/early September) was 465 spider mites per leaflet in 1973; the highest on a winter planting, 980 per leaflet in 1980. At these mite densities, plants were severely stunted or killed and yields were significantly reduced. Although such high populations do not occur every year, our field data indicate that natural populations of the spider mite can reduce strawberry yields by 10 to 15 percent at various periods during the season.

In both summer and winter plantings in southern California, the two-spotted spider mite usually was unevenly distributed and in low numbers through February (fig. 1). The spider mite population then increased rather steadily during March to a peak in late April or early

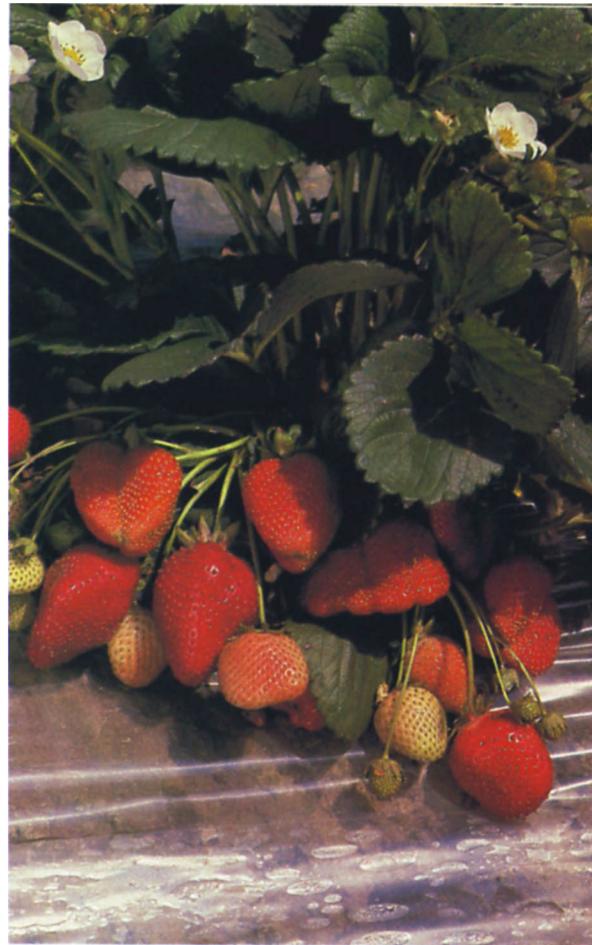
May, before declining abruptly to low numbers. Densities of predators usually closely paralleled fluctuations in the spider mite population, although their numbers were generally low when compared with the available prey. In most years, the predator:prey ratio was too low to prevent substantial economic loss for fresh market strawberry growers.

We recorded ten insect species and nine phytoseiid mite species as predators of the two-spotted spider mite during our studies. Nine of the insects and two of the predatory mites occurred annually in high enough numbers to be a major factor in natural control of the spider mite. Our 1975 study showed that these predators can be conserved and integrated with a selective miticide (cyhexatin) for more effective control of the two-spotted spider mite in commercial strawberry plantings. Such an integrated approach would help reduce the number of miticide applications, and thereby help delay the onset of miticide resistance.

The following predators are the ones most commonly encountered with two-spotted spider mites in strawberries. Most of them are also associated with spider mites on other California crops.

continued

Yields of commercial strawberry plantings, which can reach 26 tons per acre, may be severely reduced by the tiny two-spotted spider mite.





Six-spotted thrips adult



Six-spotted thrips pupa



Cecidomyiid adult



Cecidomyiid larva



Spider mite destroyer adult



Spider mite destroyer larva



Oligota oviformis adult



Oligota oviformis larva



Minute pirate bug adult



Minute pirate bug nymph



Big-eyed bug adult



Big-eyed bug fifth-stage nymph



Brown lacewing adult



Brown lacewing larva



Green lacewing adult



Green lacewing larva



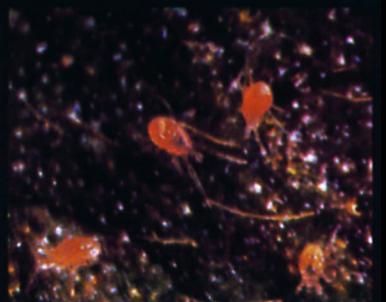
Dusty wing adult



Dusty wing larva



Western predatory mite adult (top)



Phytoseiulus persimilis adult

Most important predators

Based on numbers present annually, the most important predators are:

Six-spotted thrips

Scolothrips sexmaculatus (Pergande)
(Thysanoptera: Thripidae)

The adults, averaging 1 mm in length, are pale yellow with three dark spots on each forewing, which distinguish them from other thrips on strawberry. The eggs are inserted into soft plant tissue, with only a slightly raised area indicating their presence. There are two larval stages as well as a prepupal and pupal stage. All are translucent-white with red compound eyes. The prepupal and pupal stages are mobile, but nonfeeding. Both larvae and adults actively feed on all spider mite stages.

The six-spotted thrips was the predominant predator recorded on strawberry in our annual studies in southern California from 1964 through 1977. For example, it was 84.3 and 72.5 percent of the total predator population in 1976 and 1977, respectively.

Feltiella acarivora (Felt)

(Diptera: Cecidomyiidae)

The long-legged adults of this cecidomyiid fly are greyish brown on the back, cream colored underneath, and about 1.5 mm long. The subcylindrical, slightly curved, clear, light amber eggs, averaging 0.23 by 0.9 mm, are laid singly on the undersides of leaflets. Early-stage larvae are pinkish orange. Mature larvae are reddish orange and average 1.5 mm in length. The larvae move slowly and feed primarily on spider mite egg and larval stages. Pupation occurs in a rather flat, ovoid, greyish white cocoon spun on the underside of leaflets near the midvein or the juncture of two veins.

Feltiella acarivora was the predominant predator in test plots in 1978 and 1979, accounting for 61.5 and 65.8 percent, respectively, of the total predator population.

Spider mite destroyer

Stethorus picipes Casey
(Coleoptera: Coccinellidae)

The black adults are hemispherical, average 1.3 mm long by 1 mm wide, and are densely covered with fine white hairs (setae) that give a glossy sheen to the body. The pinkish white to orange, oblong-ovoid eggs (about 0.34 mm long by 0.22 mm wide) are laid singly on the undersides of leaflets. Early larval stages are light chocolate brown with four blackish spots on the back (dorsum) of the thorax. Mature larvae are dark gray to blackish and about 2.3 mm long. The flattened, dark mahogany pupae (averaging 1.4 mm long by 0.94 mm wide) are fastened to the undersides of leaflets by their anal end. Larvae and pupae are sparsely covered by long, greyish white hairs.

Both larvae and adults actively feed on all spider mite stages. In 1980, the spider mite destroyer was the predominant predator in our research plots, accounting for 43.8 percent of the predator population.

Less abundant predators

The following predators are present in lower, more variable numbers and are thus considered less important generally:

Oligota oviformis Casey

(Coleoptera: Staphylinidae)

The black adult, about 1.6 mm long by 0.6 mm wide, has short wing covers (elytra). It typically carries its head bent under vertically and its abdomen strongly curved upward, a characteristic distinguishing this staphylinid from other adult predators on strawberry. The ovoid, faintly reticulated (marked) eggs (0.36 by 0.25 mm), laid singly on the undersides of leaflets, are greenish yellow at first, changing to pinkish orange to orange just before hatching. The first two larval stages are shiny-clear with a greenish tint to the back (dorsum) of the

body. Mature larvae (about 2.4 mm long) are light pinkish orange and have a black spot on the dorsum of the eighth abdominal segment, which distinguishes these from other predatory larvae on strawberry. Mature larvae drop to the ground and pupate in the soil in silken cocoons. Both larvae and adults feed on all spider mite stages.

Minute pirate bug

Orius tristicolor (White)
(Hemiptera: Anthocoridae)

The black adults, somewhat flattened and ovoid with black and white wings, are about 1.8 mm long and 0.7 mm wide. The eggs, which are laid primarily in the leaf petiole, stem, and leaf midrib, with only the round, concave egg cap protruding slightly above the surface, are seldom seen by the casual observer. The nymphs (immature stages) are usually yellowish pink but also may be amber or brownish, especially toward the rear. Later-stage nymphs generally are shaped like the adults and are equally active. Both nymphs and adults have prominent beaks, and both feed on all stages of the spider mite.

Big-eyed bug

Geocoris punctipes (Say)
(Hemiptera: Lygaeidae)

Adults are dark pinkish grey and ovoid, averaging 3.8 mm in length by 1.8 mm in width. Large, compound eyes extend conspicuously from the side of the head. The pinkish white eggs, deposited singly on the undersides of leaflets, are nearly cylindrical with longitudinal striations and average 0.88 by 0.36 mm. Conspicuous red eye spots are visible through the membrane of the egg just before hatching. The pinkish gray nymphs superficially resemble the adults but are more robust and have developing wing pads. Both adults and nymphs move rapidly, drop quickly from plants when disturbed, and feed on all stages of the spider mite.

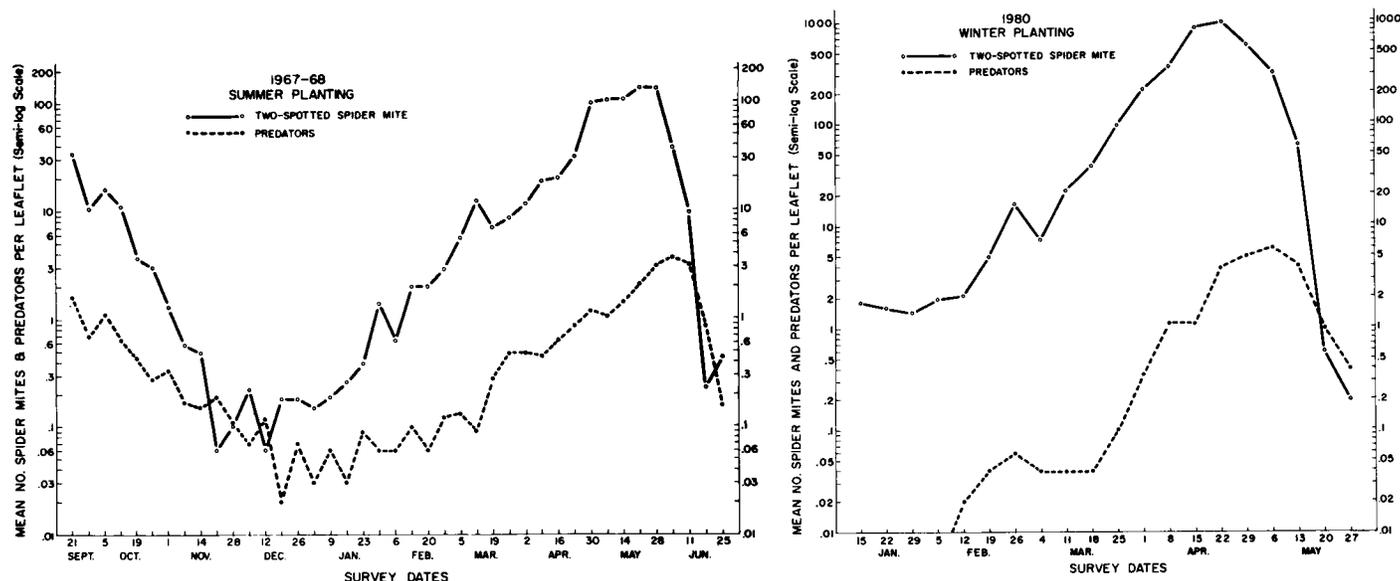


Fig. 1. In both strawberry plantings, two-spotted spider mites and their predators increased from low numbers in January and February to a peak in late April or early May, then declined abruptly.

Brown lacewing

Micromus substanticus (Walker)
(Neuroptera: Hemerobiidae)

Members of the Hemerobiidae are commonly referred to as brown lacewings. The *M. substanticus* adult is brown and averages 7.1 mm in length from the front of the head to the tips of the wings, which are folded rooflike over the body when at rest. Both body and wings are covered with brown hair. The oblong-ovoid eggs, laid singly and horizontally on the undersides of leaflets, average 0.9 by 0.38 mm. They are opaque white when first laid, becoming pinkish orange near hatching, and have faint spiral markings on the surface. The slender larvae are rust-red dorsally with pinkish red markings laterally on the body, becoming less distinct toward the rear on the abdominal segments. Pupation occurs in a thin, loosely woven silk cocoon spun primarily on the undersides of leaflets. Brown lacewing larvae feed voraciously on all stages of the spider mite.

Although brown and green lacewing larvae are superficially similar, the mouthparts (mandibles) of brown lacewing larvae are shorter and stouter. Additionally, the rings (annulae) on the basal half of the antennae of brown lacewing larvae are closer together than those (wider rings) of green lacewing larvae. Larvae of brown lacewing are more common than those of green lacewing on strawberry early in the growing season.

Green lacewings

Chrysopa spp.
(Neuroptera: Chrysopidae)

The adults, averaging 13.9 mm in length to the wing tips, are distinctly green with golden compound eyes and delicate, greenish, iridescent wings that typically are held rooflike over the body when at rest. Each egg is laid on the end of a long, thin stalk attached primarily to the undersides of leaflets. The oblong-ovoid eggs, averaging 0.91 by 0.39 mm, are creamy white to light green and darken just before hatching. The larvae, about 6.25 mm in length, range from pinkish white to rust-red with whitish areas on the back and sides of the body, becoming less distinct toward the rear. Pupation occurs in an oval, whitish cocoon of closely woven silk, which is formed primarily on the undersides of leaflets. Green lacewing larvae feed on all stages of the spider mite as well as on soft-bodied insects, eggs, and small larvae. Adults of some species are carnivorous; others feed on nectar or honeydew.

Dusty wing

Conwentzia californica Meinert
(Neuroptera: Coniopterygidae)

Members of the Coniopterygidae commonly are referred to as dusty wings. The greyish white adult of *C. californica* is about 3 to 4 mm long. The wings are covered with a greyish powder and, like those of the lacewings, are folded rooflike over the body when at rest. The oval, pinkish yellow eggs are about 0.5 by 0.23 mm, with faint hexagonal surface markings, and are laid singly, usually on the

undersides of leaflets. The larvae are pinkish white with reddish orange, variable patterns dorsally on the body, which is broad in the middle, tapering at both ends. This color pattern separates *C. californica* larvae from other predaceous larvae on strawberry. Pupation occurs in a cocoon consisting of a double layer of silk, an inner compact layer more or less oval in shape, and an outer flat, loosely woven web. The outer covering extends beyond the inner cocoon, making it appear flat on the leaf. Both larvae and adults feed on all stages of the spider mite, but the larvae are more voracious.

Western predatory mite

Typhlodromus occidentalis (Nesbitt)
(Acari: Phytoseiidae)

Gravid (egg-laying) females are light amber, pear-shaped, slightly flattened on top, and about 0.37 mm long by 0.24 mm wide. The eggs are oval and almost colorless. The larvae are whitish and slow moving. The nymphal stages (protonymph and deutonymph) resemble the adults, but are smaller. All stages feed on the spider mite.

Typhlodromus occidentalis is the most common of nine predaceous phytoseiids associated with the two-spotted spider mite on strawberry in southern California. *Typhlodromus arboreus* Chant, *Amblyseius californicus* (McGregor), *A. brevispinus* (Kennett) and *A. hibisci* (Chant) are the next most common native species, in that order.

Phytoseiulus persimilis Athias-Henriot
(Acari: Phytoseiidae)

Gravid females of this introduced (exotic), predaceous, phytoseiid mite are orange, globose, and about 0.43 mm long by 0.31 mm wide. The oval eggs are a light pinkish orange. Larvae are greyish white and slow moving as compared with the females, which move very rapidly and disperse considerable distances in search of prey. The two nymphal stages closely resemble the adult female, and all three feed on all stages of the spider mite. The larvae do not feed.

In nine experimental studies from 1964 through 1975, we successfully controlled the two-spotted spider mite on strawberry in southern California, using mass releases of *Phytoseiulus persimilis* early in the growing season. Surveys in 1975 and 1976 showed that *P. persimilis* was well established in the Oxnard area of Ventura County, where it was released in commercial strawberry fields from 1971 through 1977, and where it is considered an important factor in suppression of the two-spotted spider mite.

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Labor trends

John W. Mamer □ Philip L. Martin

California's 82,000 farms employ 600,000 hired workers at some time during the year to tend livestock and to plant and harvest crops. Many of these hired workers are employed in agriculture only a few days or weeks. California farmers have come to depend on a large work force that accommodates itself to their seasonal labor needs. The United States labor force is now growing at a decreasing rate and is projected to do so until 1995. In this article we discuss the changing labor force, adjustments that farm employers can make, changes in the California farm labor market that have emerged in the past two decades, and issues that arise with the increasing employment of foreign workers.

Changing labor force

For California agriculture, the most significant labor force changes are the slowing down in the rate of growth, the increasing average age, and the increasing relative importance of females (U.S. Department of Labor middle growth projections to 1995).

The U.S. labor force (individuals 16 years and older who are employed or unemployed but looking for work) grew by 5.7 million during the 1950s, 12.1 million in the 1960s, 20.1 million in the 1970s. An increase of 18 million is projected for the 1980s. During the next decade, growth will be concentrated in the 25 to 54 age group, reflecting its increasing average age. Fully two-thirds of the labor force growth will be a result of adult women deciding to work (by 1995, 79 percent of all women 25 to 54 years of age are expected to be in the labor force, as compared with 33 percent in 1950).

These trends will affect California agriculture. Agriculture usually hires young men for arduous harvest jobs, adult men and women for easier hoeing and pruning jobs, and adult men for irrigation and equipment operator jobs. Many young men begin to harvest crops when they are 18 to 24, continue to do