the decollate snail was 65 feet in three months in a sprinkler-irrigated grapefruit grove near Hemet, Riverside County. Assuming the effectiveness of baits will be dispelled within four weeks, a two-tree buffer would suffice to protect developing colonies of the decollate snail. As the snails disperse, the buffer zone should be advanced ahead of them.

We believe the most effective method of uniformly building up the decollate snail would be to broadcast, at first, 50 or more snails per tree over an entire grove. This release method presumes a ready supply of decollate snails and a relatively low initial population of brown garden snail, as would be expected after a baiting program. This method may also be used as a preventive measure before brown garden snail moves into a clean grove from neighboring infested properties. On their own initiative, certain major citrus-producing companies in southern California have begun to mass-produce decollate snail for release against brown garden snail on their properties.

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California red scale predator may create citricola control dilemma

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Sooty mold fungus on navel orange leaves is result of citricola scale infestation.

Approximately half of California's citrus is grown in the San Joaquin Valley along the western foothills of the Sierra Nevada. The climate is sufficiently uniform that the severity of pest species and effectiveness of natural enemies do not vary greatly from one part of the area to another. Although a large number of insect and mite species are occasionally injurious to citrus, only ten are potential economic pests, capable of either reducing the crop yield or lowering the market grade of the fruit if population densities are not suppressed either naturally or artificially.

Currently, chemical agents are required in citrus pest management to control all of the ten major pests except twospotted spider mite and some scale insects. For example, insecticides are needed to reduce numbers of citrus cutworm and fruittree leafroller larvae in some groves and to prevent injury by citrus thrips in most groves. Acaricides are applied to control citrus red mite, unless climatic conditions or a naturally occurring virus limits their numbers. Such sprays also control twospotted spider mite, which is becoming more widely distributed in the Central Valley each year.

Predators and parasites also help control some of the important citrus pests. Sixspotted thrips, *Scolothrips sexmaculatus* (Pergande), can be an effective predator of twospotted spider mite. The parasitic wasps *Metaphycus luteolus* (Timberlake) and *Comperiella bifasciata* Howard keep brown soft scale and yellow scale, respectively, below injurious levels, and the Vedalia lady beetle, *Rodolia cardinalis* (Mulsant), controls cottonycushion scale.

For these natural enemies to be effective, pesticide applications must either be avoided or be carefully timed in controlling target pests. However, beneficial fauna may have developed tolerances to pesticides, as has been indicated in the last few years by relatively few outbreaks of nontarget pests following applications of commonly used insecticides and acaricides.

The remaining two major pests, California red scale (CRS) and citricola scale, must be considered together. Currently, chemical applications for CRS also control citricola scale. If present attempts to develop biological or other nonchemical controls of CRS are successful, citricola scale may return to its pre-1950 status as a severe pest. Our purpose here is to present information to encourage citrus integrated-pest-management researchers to develop management techniques for these two pests concurrently.

History of two scale pests

Citricola scale has been an economically important pest of San Joaquin Valley citrus since the early 1900s, but CRS was not found on citrus until the mid-1950s. Following World War II, citricola scale was effectively controlled by many of the new organochemicals, and shortly thereafter, CRS became established in most Central Valley citrus properties. Early statewide attempts to contain and eradicate CRS, using new pesticides and oil, proved economically unfeasible once infestations became widespread. Eradication of spot infestations of CRS was often successful, but inspection schedules were inadequate and reinfestation occurred from undetected infestations. The regular use of parathion in these programs virtually eliminated citricola scale, because the required dosage for CRS control far exceeded that needed for citricola scale control.

Attempts to introduce, colonize, and permanently establish a number of natural enemies of CRS are continuing. Apparently, introduced parasites that are effective in southern California have not been established in Central Valley citrus orchards.

At least two species of *Metaphycus*, including *M. helvolus* (Compere) and *M. luteolus* (Timberlake), can attack citricola scale but are ineffective as parasites in the Central Valley. These parasites prefer to oviposit their eggs at a time of year when citricola scale is too small, and therefore are more successful on multiple-generation hosts, particularly brown soft scale. Citricola scale has only one generation a year; eggs hatch in early spring, and the young scale does not increase in size until about two months before the adult stage appears the following year.

Pest management plots

A mature navel orange block at the University of California's Lindcove Field Station in Tulare County was acquired in 1974 to compare minimum effective levels of pesticides with an untreated check. Populations of the insects and mites and fruit production in checks and treated plots were assessed. Before 1974, these trees had been sprayed each year to reduce infestations of citrus thrips, citrus red mite, and CRS. No citrus worm control was necessary in this block. The incidence of these pests was uniform throughout this grove at the onset of this study and, with the exception of sprays to control these three pests in the treated plots, all cultural practices have been the same in the entire planting since 1974.

Pesticides used to control citrus thrips and citrus red mite are not effective scalicides and did not affect citricola scale and CRS population densities. Parathion at 6 pounds of active ingredient or Supracide (methidathion) at 4 pounds active ingredient per 1,500 gallons of water per acre was applied to all but the untreated plot once each year for CRS control.

In 1977 honeydew and sooty-mold fungus were observed on some check plot trees. The honeydew was excreted by a low-density population of citricola scale that had not been noticed during the counts of the other pests before this time. Field counts were made by counting 20 leaves from the north side of each of 10 trees in the treated and untreated plots. Citricola scale counts have been made each summer since it appeared in 1977. The number of fruit infested with CRS was determined at harvesttime when all of the fruit was picked from the same 10 trees in the plots each year.

Results and discussion

The percentage of oranges infested with CRS varied each year in the untreated plots, whereas CRS has not been found on any fruit in the treated plots since the first year, 1974. No citricola scale has been found in the treated plots since 1977, when they were first observed in the untreated plot. Fruit from the check plot was not of market grade because of the heavy CRS infestation on the rind. In any case, these fruit would not have been accepted in a packinghouse because of the large amounts of sooty-mold fungus and honeydew produced by the citricola scale.

The pesticides used to control CRS in this citrus grove have contributed to the elimination of this scale from the fruit, whereas the parasites present in the untreated plot did not reduce CRS population densities below an economic level. Citricola scale did not become apparent until trees had been left untreated for four years. Seven years after treatments were discontinued, these trees have become so heavily infested with citricola scale that serious losses to future crops will probably occur.

If an effective parasite of CRS had been established in this untreated plot, citricola scale would now need a pesticide application that probably would eliminate the CRS parasites. Nonchemical methods to reduce injurious effects of CRS are essential, but unless citricola scale is also controlled by some method besides organochemical sprays, it may replace California red scale as the most serious citrus pest in the Central Valley.

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Major Citrus Pests in San Joaquin Valley, California*

LEPIDOPTERA ("citrus worms")
Citrus cutworm, *Xylomyges curialis* Grote
Fruittree leafroller, *Archips argyrospilus* (Walker)
(Both are distributed throughout most of the citrus acreage but are not necessarily annually recurring economic pests.)

THYSANOPTERA *(thrips)*
Citrus thrips, *Scirtothrips citri* (Moulton)

ACARINA (mites)
Citrus red mite, *Panonychus citri* (McGregor)
Twospotted spider mite, *Tetranychus urticae* Koch
(Distribution range of twospotted spider mite is increasing; apparently is a recurring annual economic pest when established.)

HOMOPTERA (scale insects)
Brown soft scale, *Coccus hesperidum* L.
Yellow scale, *Aonidiella citrina* (Coquillett)
Cottonycushion scale, *Icerya purchasi* Maskell
California red scale, *Aonidiella aurantii* (Maskell)
Citricola scale, *Coccus pseudomagnoliarum* (Kuwana)
(Citricola scale is present at low population densities in all Central Valley citrus; has no effective natural enemies but is suppressed by scalicide sprays.)

*Listed in taxonomic groupings and in the order in which controls are initiated from spring through summer.

Comparison of California Red Scale (CRS) and Citricola Scale Populations from Sprayed and Unsprayed Plots*

	Fruit infested with live CRS		Average no. live citricola scale/leaf†	
Year	Sprayed	Unsprayed	Sprayed	Unsprayed
	%	%		
1974	1.0	16.8	—	—
1975	0	37.1	—	—
1976	0	47.0	—	—
1977	0	52.3	0	0.5
1978	0	36.4	0	8.6
1979	0	68.9	0	10+

*Sprayed with either parathion or Supracide (methidathion) once each year to control CRS.
†Citricola scale counts from 20 northside leaves per tree; average shown as 10+ when counts reach 200 before 20 leaves are examined.