Biological Control

Conservation biological control in California stone fruit: A case study of San Jose scale and its aphelinid parasitoids

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Abstract: The aphelinid parasitoids of San Jose scale, *Diaspidiotus perniciosus* (Comstock), were monitored using pheromone-baited traps for three growing seasons (2000-2002) throughout the central San Joaquin Valley of California. The fields monitored were commercial blocks of peach, plum, and nectarine under two insecticide regimes: reduced-risk materials (low mammalian toxicity, low persistence) and conventional materials (neurotoxins). Trapping data suggest *D. perniciosus* populations were suppressed primarily by dormant-season insecticide applications and spring parasitism. Acreage using reduced-risk insecticides tended to have higher San Jose scale populations, although several blocks that had been using reduced-risk materials for many years had very low San Jose scale populations.

Parasitism was measured in 2001 and 2002 by establishing sentinel San Jose scale colonies on potted nectarine saplings and then placing the saplings within the tree canopies of monitored fields. Three parasitoid species were reared from sentinel San Jose scale: *Encarsia perniciosi* (Tower), *Aphytis vandenboschi* DeBach & Rosen, and *A. aonidiae* (Mercet). Parasitism was significantly higher in blocks managed under the reduced-risk program (17.1%), compared with parasitism levels found in conventionally managed blocks (5.2%). No significant correlation was found between parasitism levels, trap counts, and fruit damage.

Materials and Methods

With the cooperation of eight stone fruit growers in the San Joaquin Valley of California, orchards were monitored for SJS and its aphelinid parasitoids during the growing seasons of 2000, 2001, and 2002. Commercial peach, plum, and nectarine orchards ranging in size from 8 to 34 acres were monitored using sticky cards baited with San Jose scale lures (Trécé Co.). Most of the varieties were divided into two blocks, with a Reduced-Risk treatment regime and a Conventional regime adjacent to each other. Traps were set up at least one per five acres, and 70 m apart. Weekly counts were made; all trap-count means are per-trap, per-date.

Parasitism was measured during the growing seasons of 2001 and 2002 by establishing sentinel San Jose scale on potted nectarine saplings and taking the saplings out to the monitored orchards. Approximately 400 SJS were present on each sapling, and the saplings were mounted on the scaffolds of 6 trees in the monitored blocks. The saplings were placed in the respective blocks for one month, generally late March through late April, when the overwintered parasitoids began emerging. In 2001, six blocks received the saplings, and in 2002, seven blocks received

saplings. Insects on saplings were brought back to the University of California Kearney Agricultural Center for rearing and dissection. Two of the six trees placed in a given block were set aside for rearing and, of the remaining four, 50 SJS per tree were dissected for parasitoid activity. Rearing cages allowed for species identification of adult parasitoids, and the dissections allowed for quantification of parasitism and host-feeding.

Results and Discussion

Trapping. San Jose scale, *Encarsia* and *Aphytis*, were trapped and counted from early March through late September during the growing seasons of 2000, 2001, and 2002. Over the course of the three seasons, mean per-trap counts were highest for *Encarsia* (43.04 ± 6.02), followed by San Jose scale (35.10 ± 8.91), and then *Aphytis* (1.77 ± 0.28). Only the *Aphytis* counts were significantly different from either *Encarsia* or San Jose scale (Fisher's PLSD; $P < 0.001$).

In 2000 and 2001, more SJS and *Encarsia* were caught in the Reduced-Risk (RR) blocks compared to the Conventional (CO) blocks, but in 2002 the phenomenon appeared to be reversed (Table 1): more SJS and *Encarsia* were caught in CO blocks, though none of the means were significantly different due to the high seasonal variability. A decline in the mean trap-catch was noted each year for San Jose scale, *Encarsia*, and *Aphytis*. The San Jose scale flight typically emerged by mid-March, peaking in early April, and the parasitoid emergence followed a similar pattern.

Parasitism. Three species of Aphelinidae emerged from the sentinel scale: *E. perniciosus*, *A. vandenboschi*, *A. aonideae*. Over the course of the two years, species-specific parasitism (excluding host-feeding) was significantly higher in RR blocks for both *Encarsia* and *Aphytis* (Table 2).

E. perniciosi parasitism was higher than that of both *Aphytis* species combined ($P < 0.001$); however, when host-feeding by *Aphytis* is considered in addition to its parasitism level, the *Aphytis* contribution to scale suppression exceeds that of *E. perniciosi* (Table 2). The combination of parasitism and host-feeding by all three parasitoid species averaged 27.9% scale mortality in RR blocks and 11.2% mortality in CO blocks (Fig. 1).

These data suggest that bloomtime sprays in conventionally managed blocks may be inhibiting the activity of SJS parasitoids. These findings are especially interesting in light of the fact that more parasitoids (though not significantly) were caught on sticky-traps in CO blocks in 2002. We expected to see parasitism levels corresponding to their numerical representation, but it appears that parasitoids are encountering levels of pesticide residue in conventionally managed blocks that inhibit their ability to successfully mate and find suitable hosts. Conservation biological control of SJS in stone fruit systems will likely require that broad-spectrum materials be used as little as possible during bloom and for several weeks thereafter. Control of critical pests (thrips, peach twig borer, and oriental fruit moth) during this time can be accomplished using reduced-risk materials and IPM approaches.

Table 1. Comparisons of mean (± SEM) number individuals caught per trap in sticky cards baited with synthetic San Jose scale pheromone in blocks managed under reduced-risk (RR) or conventional (CO) insecticide programs

Year	Insecticide Program	Mean (± SEM) no. caught/trap		
		SJS	*Encarsia*	*Aphytis*
2000	RR	69.26 ± 46.29a	79.74 ± 9.86a	2.35 ± 0.89a
	CO	57.80 ± 44.51a	44.06 ± 12.56b	2.19 ± 0.95a
	Both	63.53 ± 30.33	61.90 ± 9.59	2.27 ± 0.61
2001	RR	49.64 ± 16.16a	46.62 ± 14.27a	2.29 ± 0.67a
	CO	46.47 ± 11.87a	38.57 ± 7.56a	2.07 ± 0.81a
	Both	48.58 ± 11.13	43.93 ± 9.64	2.22 ± 0.50
2002	RR	5.11 ± 2.88a	30.44 ± 13.55a	0.99 ± 0.45a
	CO	13.92 ± 10.87a	34.38 ± 15.39a	1.52 ± 0.68a
	Both	9.47 ± 1.91	31.97 ± 9.93	1.19 ± 0.38
2000-02	RR	35.23 ± 11.52a	46.10 ± 8.71a	1.71 ± 0.36a
	CO	34.91 ± 14.50a	38.45 ± 7.65a	1.87 ± 0.44a
	Both	35.10 ± 8.91	43.04 ± 6.02	1.77 ± 0.28

For each year, means in the same column followed by the same letter are not significantly different ($P > 0.05$). All tests of significance Fisher's PLSD.

Table 2. Comparisons of SJS parasitism across multiple stone fruit varieties and pest management regimes

		Average proportion ± SEM, by category[1]				
		Parasitism				
Year	Block[2]	By *Encarsia*	By *Aphytis*	Host-fed	Dead	Alive
2001	AB-*RR*	0.23 ± 0.03a	0.08 ± 0.02a	0.08 ± 0.02c	0.20 ± 0.03a	0.40 ± 0.04d
	ZL-*RR*	0.09 ± 0.02b	0.02 ± 0.01bc	0.31 ± 0.03a	0.07 ± 0.02b	0.51 ± 0.04c
	BP-*RR*	0.13 ± 0.02b	0.09 ± 0.02a	0.19 ± 0.03b	0.06 ± 0.02b	0.53 ± 0.04c
	BP-*CO*	0.02 ± 0.01c	0.06 ± 0.02ab	0.05 ± 0.02c	0.06 ± 0.02b	0.82 ± 0.03a
	RJ-*RR*	0.12 ± 0.02b	0.01 ± 0.01c	0.13 ± 0.02b	0.02 ± 0.01b	0.71 ± 0.03b
	RJ-*CO*	0.01 ± 0.01c	0.01 ± 0.01c	0.14 ± 0.02b	0.02 ± 0.01b	0.82 ± 0.03a
	Avg *RR*	0.14 ± 0.01a	0.05 ± 0.01a	0.19 ± 0.01a	0.08 ± 0.01a	0.55 ± 0.02b
	Avg *CO*	0.01 ± 0.01b	0.03 ± 0.01b	0.10 ± 0.02b	0.04 ± 0.01b	0.82 ± 0.02a
2002	ZL-*RR*	0.12 ± 0.02a	0.01 ± 0.01c	0.02 ± 0.01b	0.08 ± 0.02c	0.77 ± 0.03b
	BP-*RR*	0.05 ± 0.02c	0.08 ± 0.02ab	0.01 ± 0.01b	0.15 ± 0.03ab	0.71 ± 0.03bcd
	BP-*CO*	0.06 ± 0.02bc	0.01 ± 0.01c	0.03 ± 0.01b	0.21 ± 0.03a	0.68 ± 0.04cd
	RJ-*RR*	0.11 ± 0.02a	0.11 ± 0.02a	0.02 ± 0.01b	0.11 ± 0.02bc	0.65 ± 0.04d
	RJ-*CO*	0.08 ± 0.02ab	0.04 ± 0.02bc	0.07 ± 0.02a	0.07 ± 0.02cd	0.74 ± 0.04bcd
	SR-*RR*	0.08 ± 0.02ab	0.06 ± 0.02b	0.08 ± 0.02a	0.02 ± 0.01d	0.74 ± 0.03bc
	SR-*CO*	0.01 ± 0.01c	0.01 ± 0.01c	0.01 ± 0.01b	0.02 ± 0.01d	0.96 ± 0.01a
	Avg *RR*	0.09 ± 0.01a	0.06 ± 0.01a	0.03 ± 0.01a	0.09 ± 0.01a	0.72 ± 0.02b
	Avg *CO*	0.04 ± 0.01b	0.02 ± 0.01b	0.03 ± 0.01a	0.10 ± 0.01a	0.81 ± 0.02a
Both Years	Avg *RR*	0.11 ± 0.01a	0.06 ± 0.01a	0.11 ± 0.01a	0.08 ± 0.01a	0.63 ± 0.01b
	Avg *CO*	0.03 ± 0.01b	0.02 ± 0.01b	0.06 ± 0.01b	0.07 ± 0.01a	0.81 ± 0.01a

For each year, means in the same column followed by the same letter are not significantly different ($P > 0.05$). All tests of significance Fisher's PLSD.

[1] SJS categorized as parasitized by *Encarsia*, parasitized by *Aphytis*, host-fed by *Aphytis*, dead by unknown causes, and alive with no signs of parasitism or host-feeding.

[2] $N = 200$ SJS/block (50 SJS dissected/tree, 4 trees/block). "BP," "RJ," "ZL," "AB," and "SR" respectively denote 'Bright Pearl' nectarines, 'Red Jim' nectarines, 'Zee Lady' peaches, 'Autumn Beaut' plums, and 'Summer Red' nectarines. "RR" denotes a reduced-risk management program; "CO" denotes a conventional pest management program.

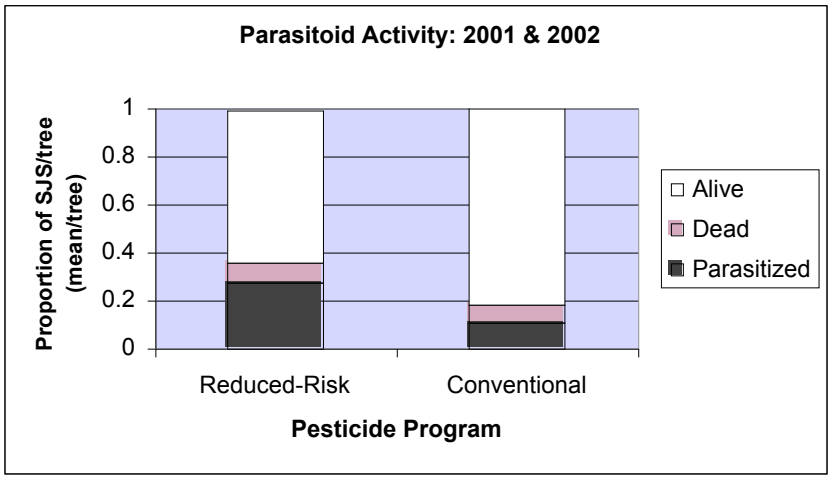

Figure 1. Proportion of sentinel SJS categorized as alive, dead, or parasitized in blocks under Reduced-Risk or Conventional insecticide regimes.