SUMMARY OF SAN JOSE SCALE RESEARCH 2002

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Project Title: Biology and ecology of San Jose scale parasitoids

Almond growers lose millions of dollars to insect pests each season. One of the key "secondary pests" is the San Jose scale (SJS), *Diaspidiotus* (formerly *Quadraspidiotus*) *perniciosus* (Comstock). In some orchards, especially in the more southern regions of the San Joaquin Valley, high densities of SJS can cause almond branches to dieback and defoliate. A multidisciplinary research team was formed in 1998 to improve SJS control programs and determine causes for recent SJS outbreaks in almond and stone fruit (this team includes Walt Bentley, Beth Grafton-Cardwell, Frank Zalom, and Kent Daane), with research and demonstration projects funded by the Almond Board of California, California Tree Fruit Agreement, California Cling Peach Advisory Board and CDFA's Department of Pesticide Regulation. A unifying thread tying individual research projects together was the determination of the negative or positive effects of replacing organophosphate treatments with least-toxic spring and summer treatments. The current research projects include: SJS sampling, insecticide resistance, in-season oil applications and the effectiveness of natural enemies – which is the emphasis of my laboratory.

In 1999-2000, we conducted intensive field sampling to investigate the SJS population outbreaks, looking specifically at the impact of natural enemies and methods to manipulate natural enemy numbers. In 2001-02, we used laboratory or controlled field experiments to take a closer look at parasitoid biology. Our 2002 research can be divided into two sections, (1) parasitoid biology studies that focused on the temperature development of SJS and some of its primary parasitoids (*Encarsia perniciosus*, *Aphytis aonidiae*, and *Aphytis vandenboschi*) and (2) field cage studies that focused on the effectiveness of released *Encarsia perniciosus* and *Aphytis vandenboschi* on SJS densities.

Parasitoid biology. In winter 2001, we began to evaluate methods to mass rear SJS parasitoids (*Encarsia perniciosi*, *Aphytis aonidiae*, and/or *Aphytis vandenboschi*) for augmentative release. Concurrently, we investigated both SJS and parasitoid biology. Because a great deal of information has already been collected on *A. aonidiae* (by other researchers), we concentrated on *Encarsia perniciosi* and *A. vandenboschi*. In most studies, SJS was reared on butternut squash to produce squash with the desired SJS population (e.g., SJS age, density). The infested squash were provided to parasitoids for studies of host preference, parasitoid competition and temperature development. Result highlights include the following. (1) *A. vandenboschi* prefers non-gravid adult female SJS (third instar), followed by gravid female SJS and then second instars; first instars were not attacked (Figure 1). (2) *A. vandenboschi* temperature tolerance appears narrower than expected. At constant temperatures, *A. vandenboschi* took 24, 22.2 and 17.5 days to develop (egg to adult) at 20, 25 and 30°C, respectively (Figure 2). It did not develop fully at either 15 or 35°C. (3) In experiments where scale is exposed to both *A. vandenboschi* and *E. perniciosi* (which attacks the earlier SJS stages), *A. vandenboschi* always out-competes *E. perniciosi.* Each of these results has a potential impact on parasitoid performance in the field.

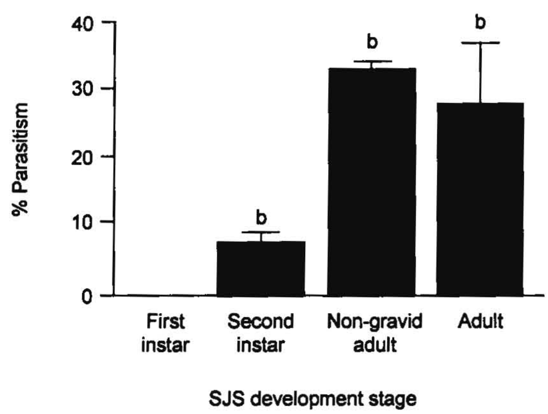

Figure 1. *A. vandenboschi* prefers to attack the larger SJS stages. This implies that when there is a new egg hatch and most of the SJS populations is small, *A. vandenboschi* may not be able to deposit eggs in the available SJS. This may lower reproduction; however, because *A. vandenboschi* "host feds," the SJS population may still be reduced during this period. The work also implies that *A. vandenboschi* may have a competitive advantage over *E. perniciosi*, which attacks smaller SJS stages, by attacking SJS after *E. perniciosi* has already deposited an egg.

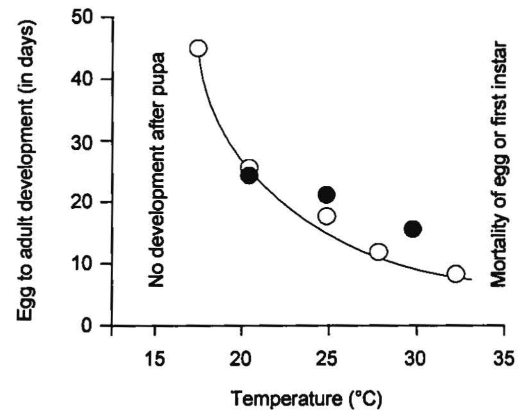

Figure 2. *A. vandenboschi* temperature development in our study (•) compared to research conducted in Utah on a different *A. vandenboschi* population (○). While the Utah work showed a nice curve of faster development with higher temperatures – up to the maximum temperature tested (33°C), we found that *A. vandenboschi* did not survive at 35°C and both fecundity and development were dramatically lower at 33°C. The results suggest that *A. vandenboschi* effectiveness may be lower during the hot periods of summer.

Field cage experiments. In 1999, we tested the potential of a commercially available parasitoid (*Aphytis melinus*) to attack SJS in the field and found this parasitoid species would host feed upon SJS but did not parasitize SJS in the field. In 2000 and 2002, we tested the effectiveness of mass-released of *E. perniciosi* and *A. vandenboschi* and showed that while *E. perniciosus* parasitized more SJS, *A. vandenboschi* caused greater SJS mortality through a combination of parasitism and host feeding. In 2002, field cage trials focused on (1) the potential competition between *E. perniciosi* and *A. vandenboschi* and (2) the effectiveness of A. vandenboschi at different times of the season. Results show that, as in insectary trials, *A. vandenboschi* out-competes *E. perniciosi.* These data continue to be intriguing as *E. perniciosi* is often more abundant in the field and points to influences of the orchard management practices or SJS field biology (e.g., distribution, size) that create a more favorable condition for *E. perniciosi*. Results from the seasonal influence on *A. vandenboschi* effectiveness are still inconclusive. Our working hypothesis is that warmer temperatures in (June-August) and the availability of small scale combine for reduced numbers of *A. vandenboschi* (and poor biological control). Cage trials have not yet provided the needed evidence to support this claim, which is backed by laboratory results.

Research plans in 2003 are to continue laboratory and field trials of *E. perniciosi* and *A. vandenboschi* biology. It is unlikely that a commercial augmentation program will be developed, however, information on parasitoid biology may prove beneficial in the development of predictive models for SJS outbreaks and needed insecticide treatments.