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Organic farming research project report submitted to the Organic Farming Research Foundation:

Project Title:

Mass-rearing and release of a locally adapted female-only strain of Trichogramma nr. platneri for supplemental control of codling moth in coastal organic apple orchards

FINAL PROJECT REPORT

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Funding provided by OFRF: $4,862

Awarded: Spring 1995

Project period: 1995 -1996

Report submitted: March 1997

Introduction

Santa Cruz County has historically been a prime apple growing region with cool, dry summers and mild winters. However, the areas of remaining apple production in Santa Cruz County; Pleasant Valley, Corralitos, and Watsonville are becoming increasingly planted to other higher-value crops (strawberries, raspberries, and lettuce) or urbanized for residential development. Conventional apple growers in these areas spray synthetic insecticides several times throughout the growing season to prevent damage by the codling moth, *Cydia pomonella*, which is the key economic pest. The environmental impacts of these sprays to pest populations (Varela et al. 1993), growers, workers, other rural residents, and consumers is of serious concern to organic farmers and the organic farming movement.

Approximately 600 acres of apple production are certified organic in Santa Cruz County. Previous OFRF-sponsored research in 1992 showed that pheromone-based mating disruption is an effective alternative to chemical sprays for low to moderate populations of codling moth in organic control programs in coastal Central California (Swezey et al., 1993; 1994). However, in some situations, especially in older standard root stock or mixed variety orchards, mating disruption does not appear to be efficacious as a single tactic. In older organic orchards or high moth pressure situations in Santa Cruz County, supplemental controls are often required in combination with mating disruption for economic control of codling moth. Previous studies have been done on controlling *C. pomonella* by augmenting populations of a natural enemy, the egg parasitoid *Trichogramma* spp. This parasitic wasp has been released in apple orchards in Canada (Yu et al. 1984a) and California (Caprile et al. 1994; McDougall, 1995) with varying levels of success. The present project proposed rearing and releasing a newly discovered, locally-adapted, female-only species of trichogramatid, *T*. nr. *platneri* from the Santa Cruz Mountains to use in combination with pheromone-based mating disruption in Santa Cruz County organic apple production systems. However, preadaptation and searching range of this parasitoid were unknown. In this study, we released females of a local population of *T*. nr. *platneri*, into an organic apple orchard, and we monitored the parasitization of sentinel codling moth eggs as a preliminary demonstration of dispersal capabilities and directional distribution of parasitoid activity.

Published studies indicate that *C. pomonella* can be controlled to some degree by augmenting populations of *Trichoqramma* spp. (Dolphin and Cleveland, 1966; Dolphin et al. 1972, Yu et al. 1984b). However, in researching the organic or alternative apple farming literature, no instance of the combination of mating disruption and inundative *Trichoqramma* releases were found to have been studied as a routine organic management practice in California, except in the recent dissertation of McDougall (1995). McDougall's research was done with an imported *T. platneri* from a commercial insectary in Southern California. This insectary population was established from parasitoids collected in the Sierra Nevada foothills, and its relationship to the platneri/minutum complex in the Santa Cruz Mountains is unknown (Platner, pers. comm.)

Although *Trichogramma* spp. are successful egg parasitoids in many agricultural systems, numbers in the wild generally are not sufficient to control occasional or persistent outbreaks of host pests (Oatman and Platner, 1985). When released in high densities (100,000 parasitoids/acre) *T. minutum*, a species found in Canada, has been shown to parasitize from 20 to 94% of codling moth eggs (Yu et al, 1984a). Similar preliminary evidence from one Northern San Joaquin Valley organic apple orchard and Sonoma County organic orchards indicates that commercial insectary-reared, sexually-reproductive *T. platneri* "shows some promise ... as a supplement for pheromones to control codling moth."(Caprile et al, 1994, McDougall, 1995). While the potential of *Trichogramma* as a biological control agent in apples has been suggested by these studies, no research has been

undertaken with locallyadapted, uniparental parasitoids in certified organic apple production systems on the Central Coast. A successful, locallyreared parasitoid could be an important addition to mating disruption programs for apples in many central coast production situations (Platner, 1993). As of Spring, 1997, a new CASFS Biological Control Laboratory *Trichogramma* rearing project with cooperating apple growers now produces and mass-releases *T.* nr. *platneri,* for biological control of codling moth in organic apple orchards. Present commercial clients include Jim Rider and Bill Peixoto (who are supporting large experimental releases in 1997), and a number of smaller orchards, including the UCSC Farm and Garden also receive parasitoids.

Previous research (with the support of OFRF) has been done with coastal apple growers in support of pheromone-based codling moth management and organic growers have now accepted and are using this method of pest control. However, in some orchards, mating disruption and other organic methods cannot alone keep codling moth damage at a manageable level. The addition of a locally-adapted egg parasitoid released at egg-laying of the first codling moth generation could make an economic difference for local organic apple growers in terms of lowered codling moth infestation at harvest. The information gathered in this study about flight and parasitism of codling moth eggs after parasitoid release in organically-managed orchards has been made available to the public through the annual "Moth Madness" growers meeting sponsored by the California Alliance with Family Farmers (CAFF) Watsonville Lighthouse Farm Breakfasts in March 1996 and 1997, and in articles in the *Santa Cruz Sentinel* and Center for Agroecology and Sustainable Food Systems (CASFS) newsletter *Cultivar* (see attached). The principal investigator now makes mass-reared parasitoids available, at cost, to local commercial organic apple growers, upon request.

Methods

In 1993, CASFS personnel collected females from two local populations of *Trichogramma* from unsprayed apple orchards in Santa Cruz County. Sample specimens were sent to the Department of Entomology, University of California, Riverside. *Trichoqramma* taxonomist Dr. John Pinto identified one population as *T.* nr. *platneri,* believing it is possibly a new, sibling species. This strain is thelytokous, meaning that only females are produced by a clonal reproductive process. It is now kept in mass culture a-t .the CASFS Biological Control Laboratory on the University of" California, Santa Cruz campus. This local accession is an excellent candidate for biological control applications in that only females (and their clonal offspring) are reared and released. Sexually reproductive *T. platneri* has been found in several hosts in many sites on the Pacific coast (Pinto et al. 1992) in avocado and almond trees, in both codling moth and other hosts in California (Pinto et al, 1991, Oatman and Platner, 1985). Our thelytokous strain is a new and significant find because a local, female-only, new parasitoid strain could be superior in effect when compared with commercial, insectary-reared, sexual *T. platneri*.

Thelytokous *T.* nr *platneri* were mass-reared in the CASFS Biological Control Laboratory on the eggs of the factitious host, *Ephestia kuhniella.* In spring-summer 1996, five releases (equivalent to 37,500 parasitoids/acre) were made from a central release cup in marked trees on a .2 acre block of semi-dwarf mixed variety red apples at the CASFS Farm apple orchard. This orchard was under a pheromone-based mating disruption program in 1996 (400 dispensers/acre; Pacific BioControl Isomate C). Before each release, laboratory-rearing codling moth eggs (laid on wax paper) were isolated and the wax paper cut around clumps of eggs. These eggs were then affixed onto a 1" x 2" piece of heavy black mounting paper.

A central tree was located in the five rows of the .2 acre orchard block and an 8-foot length of 2-inch diameter PVC pipe was inserted into the soil upright and tied to the tree trunk. This PVC pole was used as the central liberation site for all parasitoid releases. An inverted 1 pint plastic cup was

taped at a height of 5 feet from the soil surface to the northern side of the pole. Inside the cup was placed a 1x3x0.5 inch cage made of 1/4 inch gauge wire mesh. This cage had a small end opening into which *Trichogramma* pupae, glued to a laboratory egg-card, could be inserted.

On each of five successive release dates, (4/2, 4/20, 5/8, 6/10, 7/9) five square inches of "programmed" *Trichoqramma* parasitized *Ephestia* eggs were inserted into the wire mesh cage. The cup and cage served to protect the parasitized eggs from moisture, solar radiation, wind, and predators. Programmed parasitized eggs were reared for eight days at 25°C in a temperature cabinet, making them ready to emerge within 48 hours. We allowed for 48 h. emergence time in the field before beginning the evaluation procedure, and we visually verified parasitoid activity in the release cup at that time. One square inch of black mounting paper, covered evenly with host eggs and parasitized in the laboratory, contains approximately 1500 *Trichogramma* parasitoids.

In order to track the dispersal and parasitism pattern of *T.* nr. *platneri*, sentinel codling moth egg stations were placed in each of the four cardinal directions at three distances from the central release point. At distances of 1, 10, and 20 meters we set up PVC poles (same size as the central release pole) each with inverted plastic cups taped to the north side of the pole. Inside each cup was a similar wire cage containing a clump of 20-25 codling moth eggs. The objective was to provide parasitoids with abundant potential hosts at all distances.

The sentinel codling moth eggs were collected 48 h. post-placement (48-96 h. post confirmed emergence of parasitoids from the central point). Collected sentinel codling moth eggs were placed in an incubation chamber at 25°C and monitored for signs of parasitization. The eggs that were parasitized (black or darkened) were separated and reared to parasitoid emergence and their directional location and date of parasitization was noted and mapped. The cumulative release doses had as a principle objective the attainment of measurable parasitism and movement of parasitoids in the orchard by the end of the five-release program.

Results and Discussion

Figure 1 shows the results of the experimental releases. Sentinel eggs are coded as to "set out" date and presence of parasitism. For the 4/2 release, two sets of sentinel eggs were set out in the orchard on 4/4 and 4/6. The 4/4 sentinels (a) showed the most parasitization in eggs that had been set out at a distance of 1 m from the release point. The easterly direction had the highest amount of parasitization, To the west two of the eggs were parasitized and to the north two more were parasitized at the one meter distance. In this first release evaluation, there was only one instance of parasitization at a greater distance (N-10 m.) The second set (b) of 4/6 sentinels showed only three of the eggs had been parasitized at 1 m. to the south of the release point. Prevailing westerly winds during this experiment probably accounted for nearly 60 percent downwind (easterly) flight and parasitism and only 17 percent upwind (westerly) flight and activity of parasitoids.

The third group of sentinel eggs (c) were set out in the orchard on 4-22-96, after a 4/20 release of parasitoids. Four of the codling moth eggs east at 1 m. and seven eggs at N-1 m. were parasitized. Single eggs at 10 and 20 m. had also been parasitized, indicating up to 20 m flight capability.

On 5/8, a third parasitoid release and 5/10 (d) and 5/13 (e) sentinels resulted in a similar pattern of majority dispersal to the N, E, and S (only 33 percent of 5/10 and 5/13 sentinels dispersed into prevailing winds). A majority of downwind (N, E) dispersal was at 10 m., indicating the possibility of wind-aided movement. This was also the first release for which sentinel eggs had been placed on the release pole itself. At the release site there was parasitization in two E eggs and three S eggs. 5/13 sentinels (e) indicated much reduced recovery 1 week post release (only 4 parasitoids were recovered compared

with 22 parasitoids recovered 96 h. post release). This release indicates that parasitoid activity is greatest 48-96 h. post emergence.

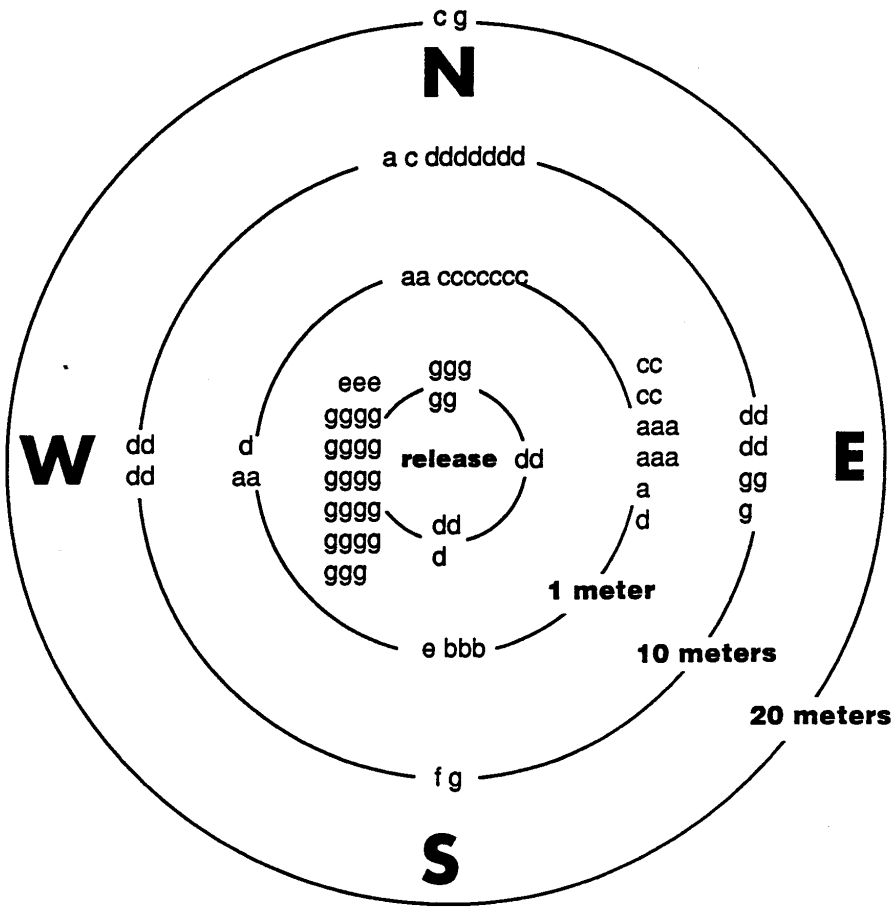
On 6/10, a fourth release of *T.* nr. *platneri* was made, but sentinel eggs were badly damaged by predators and no parasitization data could be collected from this release. The wire gauge of the mesh cages was changes from 1/4 to 1/8" inch after this release.

The final parasitoid release *T.* nr. *platneri* occurred on 7/9. Although the 7/11 (f) sentinels showed low activity (1 parasitoid at S-10 m.) the 7/13 (g) sentinels showed the highest rate of recovery of (32 parasitizations) with 70 percent of these at W-release pole position. The N-release pole position had five additional parasitoids, and the N-20 m. position had one parasitioid, again indicating up to 20 m. dispersal ability. Prevailing westerly winds were calm during this release period, possibly leading to increased local release point effects.

Using the combined data for all but the final 7/9 release (in which prevailing winds did not influence dispersal), only 18 percent of parasitism occurred in the westerly (upwind) direction and only 13 percent of parasitism occurred in the southerly direction. Parasitism (79 percent) is more frequent in downwind positions. Only 4 percent of parasitism occurred at a distance greater that 10 m. from the parasitoid release point (20 m.). These observations can be explained by theorizing a wind influenced parasitoid dispersal distance limit of 10 m. or less, and parasitoid avoidance of increased radiation or insolation environments on the southern exposures of apple trees. Longer distance (20 m.) dispersal (wind-aided?) is less likely, but was observed.

Our evaluation of these data is continuing in the form of two 1-acre increased dose release experiments in Santa Cruz County commercial organic apple orchards, and numerous smallerscale releases throughout Santa Cruz County. For commercial organic apple growers Jim Rider and Bill Peixoto, we are supervising and evaluating the release of 120,000 adults per acre in 40 release stations spaced at 20 meter intervals in the center of a 1-acre pheromone mating-disrupted orchard block. Four releases will be made at 10-day intervals beginning April 20. At cost value of each release is $50.00, making this increased dose strategy suitable for only for "hot-spot" commercial control. 48-hr field emergence programming and predator protection cages are now standard aspects of release procedure.

Smaller numbers of parasitoids for individual trees and small orchards are available at a cost of $5.00/1500 parasitoids, delivered to a Santa Cruz County address (contact Cathy Carlson at 459-5069). The importance of this research is that for the first time, a locally collected and reared, thelytokous, pre-adapted (possibly new) species of *Trichogramma, T.* nr.*platneri* is being made available to Santa Cruz County organic orchardists who desire increased biological control of codling moth. Local utilization of locally mass-produced biological control agents should be a continuing development option for the organic farming industry in Santa Cruz County.



a = sentinels set out 4-4-96
b = sentinels set out 4-6-96
c = sentinels set out 4-22-96
d = sentinels set out 5-10-96
e = sentinels set out 5-13-96
f = sentinels set out 7-11-96
g = sentinels set out 7-13-96

Figure 1. Distribution of *Cydia pomonella* sentinel eggs parasitized by *T.* nr. *platneri* released at the UCSC Farm orchard during the 1996 growing season.

Literature Cited

Caprile, J., K. Klonsky, N. Mills, S. McDougall, W. Micke, B. Van Steenwyk 1994 Insect damage limits yield, profits of organic apples. California Agriculture 48(6) 21-28.

Dolphin, R.E., M.L. Cleveland, T.E. Mouzin, and R.K. Morrison 1972 Releases of *Trichoqramma* spp.: effects on codling moth. Environmental Entomology 1: 481-484

Dolphin, R.E. and M.L. Cleveland 1966 *Trichoqramma minutum* as a parasite of the codling moth and red-banded leaf roller. Journal of Economic Entomology 59: 1525-1526.

McDougall, S.J. 1995 The potential of indundative releases of *Trichoqramma platneri* Nagarkatti and orchard sanitation for the control of codling moth, *Cydia pomonella* L. in apples in California. PhD. Dissertation, University of California, Berkeley, 155 p.

Oatman, E.R. and G.R. Platner 1985 Biological control of two avocado pests. California Agriculture 39: 21-23.

Pinto, J.D., D.J. Kazmer, G.R. Platner, and C.A. Sassaman 1992 Taxonomy of the *Trichogramma minutum* complex. Annals of the Entomological Society of America 85: 413-421.

Pinto, J.D., Stouthamer, R., Platner, G.R. Platner, and E.R. Oatman 1991 Variation in reproductive compatibility in *Trichoqramma* and its taxonomic significance. Annals of the Entomological Society of America 84:37-46.

Platner, G.R. 1993 personal communication, June 11

Swezey, S.L., P. Vossen, J. Caprile, W. Bentley, S. Blodgett, and L. Varela 1993 Planned parenthood for codling moths: mating disruption can keep populations down. California Grower, April pp.25-27

Swezey, S.L., J. Rider, M.R. Werner, M. Buchanan, J. Allison, and S.R. Gliessman. 1994 Granny Smith conversions to organic show early success in Santa Cruz County. California Agriculture 48(6): 34-44.

Varela, L.G., S.C. Welter, V.P. Jones, J.F. Brunner, and H. Riedl. 1993. Monitoring and characterization of insecticide resistance in codling moth (Lepidoptera: Tortricidae) in four western states. Journal of Economic Entomology. 86 (1) : pp. 1-10.

Yu, D.S.K., J.E. Laing, and E.A.C. Hagley. 1984a. Dispersal of *Trichoqramma* spp. in an apple orchard after innundative releases. Environmental Entomology 13: 371-374.

----------1984b. Biology of *Trichogramma minutum* collected from apples in southern Ontario. Environmental Entomology 13:13241329