


Biological Control Program

Annual Report 2010

California Department of Food & Agriculture




BIOLOGICAL CONTROL PROGRAM

2010 SUMMARY

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CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
PLANT HEALTH AND PEST PREVENTION SERVICES
INTEGRATED PEST CONTROL BRANCH

Cite as: Dale M. Woods, Editor, 2011, Biological Control Program 2010 Annual Summary, California Department of Food and Agriculture, Plant Health and Pest Prevention Services, Sacramento, California. 69 pp.

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The CDFA Biological Control Program greatly appreciates the many biologists and agriculture commissioners throughout the state whose co-operation and collaboration made this work possible.

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Cover developed by Dale Woods. Photos of native California plants utilized in host testing; clockwise from bottom middle; *Calystegia purpurata*, *Thysanocarpus curvipes*, *Packera clevelendii*, *Verbena californica* and *Stanleya pinnata*. All photos by Dale Woods. Continuing photos; weed biological control agents tested for safety from potential insect biological control agents; *Arytainilla spartiophila, Chaetorellia succinia*, and *Phrydiuchus tau*. Insect photos by Baldo Villegas

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Preface

M. J. Pitcairn

The successful control of an exotic insect pest or weed through biological control results in several significant benefits, including long term control of the target pest, a reduction in the amount of pesticides applied, and a reduction in control costs. Expenditures for pesticides, labor, and specialized equipment are substantially reduced or removed altogether, saving enormous amounts of time and money. These cost savings accrue over time and can become substantial. To get to this point, however, it is necessary for biological control scientists to devote several years to host specificity testing as part of the pre-release risk analysis of any potential exotic agent. Host specificity testing is a labor-intensive and time-consuming activity yet is the cornerstone around which predictions of risk to non-target species are made. Host specificity tests consist of exposing the candidate biological control organism to a series of potential target and non-target hosts. For weed biological control agents, the candidate is exposed to a large number of host plants. Several different methods can be employed: simple no-choice or starvation tests where the organism is exposed to a single plant species and is forced to utilize the plant or die, or complicated multiple choice tests where several plants are provided and the organism chooses the host. These tests usually occur in a quarantine facility but some tests may require an outdoor common garden study in the pest's area of origin. The costs associated with host specificity testing are very high and take several years to complete. For weed targets, host specificity testing can take three to four years but sometimes six or more years are needed for the tests to be completed.

The predictions of risk to non-target species are greatly dependent on the non-target hosts tested and experimental design. A carefully constructed host test list will result in more accurate results and better predictions of host use following the release of the control agent. Our objective is to evaluate the potential risk to non-target hosts in North America. Thus, it is critical that the non-target hosts selected for testing consist of species from North America. For weed biological control agents, as many as 50 or more North American economic and native plant species can be tested. Obtaining these hosts can be no small feat. Our efforts to support host specificity testing of several candidate insect and weed biological control agents is reflected in this year's annual report. For example, in 2010, over 60 species of native plants and varieties of commercial crops were sent to cooperating biological control researchers for inclusion in host specificity tests for biological control programs aimed at five noxious weeds. Similarly, effort was directed at obtaining non-target insect species for biological control programs for the Asian citrus psyllid, citrus leafminer, and the Diaprepes root weevil. These efforts will greatly speed-up the necessary host specificity testing, reduce the costs associated with these tests, and will lead to the release of beneficial control organisms into California much sooner.

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Field Collection of Broom Psyllids for Use in Host-Specificity Testing of a Parasitoid of Asian Citrus Psyllid

Kris Godfrey and Baldo Villegas

The Asian citrus psyllid (*Diaphorina citri* Kuwayama) was first found in southern California in August 2008. This psyllid is a threat to all citrus in California because of its ability to vector the most devastating disease of citrus, huanglongbing (or citrus greening), a disease for which there is no cure or therapy. Currently, the State of California is managing the psyllid using insecticides. This management program is not applicable throughout the state because the psyllid can be found in areas where insecticides cannot be used. Biological control may be an option for use in these areas, and strains of one parasitoid, *Tamarixia radiata* Waterson (Hymenoptera: Eulophidae), are available for field release in portions of the United States. In order to release specific strains in California, we need to provide a risk assessment for native and/or non-target psyllids in California by examining the host-specificity of *T. radiata*. The host-specificity testing is a cooperative project between the California Department of Food and Agriculture Biological Control Program and the University of California-Riverside, Department of Entomology. Two of the non-target psyllids being examined, *Arytainilla spartiophila* Foerster and *Arytaina genistae* (Latreille), can be found attacking Scotch broom, an aggressive exotic weed. The first psyllid, *A. spartiophila* was released as a weed biological control agent, and has one generation per year. The other psyllid, *A. genistae* was never released as a weed biological control agent, but was accidentally introduced into the United States. This psyllid has at least two generations per year. To obtain these psyllids for use in the host-specificity testing, populations of both psyllids had to be located, and then collected in an attempt to establish laboratory colonies. Populations of *A. spartiophila* had been reported near Garden Valley in El Dorado County, California, but *A. genistae* had not been reported from California The closest confirmed colony was in southern Oregon. The populations in southern Oregon were established many years ago, and it is likely that the psyllid has moved into California on its own.

To collect *Arytainilla spartiophila*, a Scotch broom site near Garden Valley in El Dorado County was sampled approximately every two to three weeks beginning in early March. Scotch broom plants at this site extended from the roadside southward into a dry creek bed (Figure 1A and B). Sampling was conducted by sweeping the foliage for adults and/or by collecting stems. The sweep and stem samples were returned to the laboratory where they were examined for the presence of nymphs and adults of the psyllid. Any nymphs or adults found were placed on potted Scotch broom plants and held in a greenhouse to allow for colony development. Nymphs of this psyllid were found on stems in May, and adults were collected from May through September. The collected psyllids fed upon and oviposited in the plants in the cage. However, the eggs that were laid went into diapause.

Figure 1. **A**. Scotch broom site near a roadside in El Dorado County. **B**. Scotch broom growing down to a dry creek bed from the roadside in El Dorado County.

In an attempt to get the overwintering psyllid eggs to hatch, single stems containing eggs were placed at 6°C (8L:16D) for six weeks, a regime known to cause overwintering aphid eggs to hatch. Scotch broom stems containing overwintering psyllid eggs were collected from the field at approximately monthly intervals beginning in November. Collections will continue until February or March 2011 depending upon winter weather conditions at the field site. The individual stems are secured in aqua-picks containing water to maintain the turgor of the stems. Once the chilling period is completed, the stems will be held at room temperature to allow for nymphs to hatch from the eggs. Results from the chill treatment are pending.

The second broom psyllid, *Arytaina genistae*, had not previously been recorded from California. On June 10, 2010, Baldo Villegas found adults and nymphs of this psyllid attacking French broom near Trinidad in Humboldt County, California, apparently having migrated from Oregon. These psyllids were placed on Scotch and French broom plants in a greenhouse in an attempt to establish a colony. To date, the colony has not established.

Sampling at all of the field sites will continue until enough of one or both species of psyllid nymphs have been collected to complete the host-specificity testing.

Survey for Non-target Hosts of *Diachasmimorpha kraussii* and *Fopius ceratitivorus* in Israel, 2010

Wolff Kuslitzky[1] Yael Argov[1], Charles H. Pickett, and Kent M. Daane[2]

Efforts to introduce new parasitoids into California for the biological control of olive fruit fly, *Bactrocera oleae*, have resulted in the permitting and field release of two species of *Psyttalia* (Braconidae). *Psyttalia* nr. *concolor* (ex Namibia) and *P. lounsburyi* (ex Kenya) have been released for three years with limited within-season recoveries. Most likely the transition from a wild to commercial subspecies of olive tree, *Olea europaea* presents gaps both in space and time to these parasitoids in host availability, making their permanent establishment difficult. We are therefore interested in pursuing the release of other, perhaps slightly less specific parasitoids that would have a greater likelihood of permanent establishment and impact on the olive fruit fly population. Possible candidates include species of *Diachasmimorpha* and *Fopius*, both known to specialize on *Bactrocera* and more specifically, both have been recovered from olive fruit fly. *Diachasmimorpha longicaudata* emerged from olive fruit fly collected off wild olive *O. europaea* subsp. *cuspidata* found in central China. *Fopius ceratitivorus, F. arisanus* and *D. kraussii* released into Israel for control of Mediterranean fruit fly, *Ceratitis capitata*, have been recovered from olive fruit fly infesting commercially produced olives.

Some host testing has already been completed for *D. kraussii* and *D. longicaudata*, as well as *Fopius arisanus*. While *F. arisanus* did not attack the non-target hosts *Chaetorellia succinea* in yellow starthistle flower heads or *Parafreutreta regalis* in Cape ivy galls, *Diachasmimorpha* spp. did. The populations used in our studies came from lab colonies, and originated presumably from somewhere in the Pacific Basin. It is possible, however, that the *D. longicaudata* used in our host range studies is a distinctly different strain or even species than that collected in China. Recent work in Thailand has shown that what was once considered one species of *D. longicaudata* is actually three, each with distinctly different host preferences.

The fruit fly, *C. succinia,* is one of the most effective biological controls of yellow starthistle. Israel has released several parasitoids for control of Mediterranean fruit fly, including *F. ceratitivorus, F. arisanus* and *D. kraussii*. A survey was proposed to determine whether or not these parasitoids could be found attacking *Chaetorellia* spp under natural conditions. Such information would help to support future permitting efforts for *F. ceratitivorus* or *F. arisanus*, and possibly a population of *D. longicaudata* originating from China. In a preliminary survey conducted in Israel in 2009, we found *Centaurea hyalolepis* and *C. procurrens*, plants that are closely related to *C. solstitialis,* infested by *C. succinea*; however *D. kraussii*, *F. ceratitivorus,* and *F. arisanus* never emerged. We report here on a similar but more comprehensive survey conducted in 2010 in Israel.

Samples were collected from areas where *D. kraussii* and *Fopius* spp. are established and where *Centaurea* spp. occurs. They were collected from Rehovot, Bet Dagan, Ma'agan Mikha'el, Timrat and other sites during May to August when seeds of *Centaurea* spp. were forming. Samples were collected every three weeks and consisted of about 600-700 seedheads, obtained mainly near the orchards in which *D. kraussii* had formerly been found. Seedheads of *Notobasis syriaca* and *Carthamus tenuis* were taken along with those of *Centaurea* spp. All seedheads were placed in plastic cages (35x30x15cm) with side holes for ventilation, closed with

mesh or cloth, and covered with glass. Jars with humidified paper were placed in the cages to maintain the humidity of the seedheads.

Two methods were used to collect insects emerging from samples:

1. Vertical cages: Cages were positioned vertically with an obscured glass lid, and a transparent receiver for collecting insects was placed at the top (Figure 1-bottom).
2. Horizontal cages: Cages were placed horizontally; a sheet of white paper was placed on top of the seedheads. The emerging insects that were attracted to the light and that reached the glass-lid were clearly visible with this white background. Dead insects were collected from the top of this paper (Figure 1 – top, Figure 2).

The insects were collected periodically and any spiders were removed. Collected insects were placed in test tubes and some specimens were prepared (mounted) for identification.

To establish the trophic relationship of all emerging insects, 20-40 seedheads from each sample were placed in tubes. If an adult emerged, seedheads from those samples were examined for insect remains. All insects were identified to family, and some to genus or species, and are listed in Table 1.

Figure 1. Horizontal (top) and vertical (bottom) cages used to capture emerging insects.

Figure 2. Opened horizontal cage, lid removed, used in capturing emerging insects.

Seedheads were collected one to five times per season at each of 11 localities. In total 24,500 seedheads were obtained, including: 15,000-16,800 seedheads of *Centaurea procurrens* (24 samples were obtained from 13 May 2010 to 29 August 2010); 5,500-6,300 seedheads of *C. hyalolepis* (nine samples were obtained from 30 May 2010 to 15 August 2010); 700 seedheads *of C. crocodylium* (one sample obtained on 3 May 2010); and 700 seedheads of *C. venturum* (one sample obtained on 30 May 2010). The latter two plants were collected towards the end of their growth. *Chaetorellia succinea* and an allied species, *Ch. carthami,* were present in most samples,

and were also reared from the seedheads of *Notobasis syriaca* and *Carthamus tenuis*. The number of insects emerging from collected plant material is an approximation because some individuals were destroyed by predators, especially spiders (Table 1).

Neither *Diachasmimorpha kraussii* or *Fopius* spp. were found in any of the collected seedheads in 2009 or 2010. Of the complex of parasitoids known from Israel attacking the Mediterranean fruit fly and the olive fruit fly, only the pteromalid *Cyrtoptyx ?latipes* (Rondani) was found amongst the reared parasitoids developing in seedheads of *Centaurea* spp. To date, no members of the subfamily Opiinae (to which *D. kraussi* and *Fopius* spp. belong) have been recorded emerging from fruitfly infested seedheads of *Centarurea* spp. in Israel. Similar results were obtained in our 2009 samplings.

Table 1. Number of key insects reared from seedheads of *Centaurea procurrens and C. hyalolepis*, - Israel 2010.

Name of insects	*Centaurea procurrens*						*Centaurea hyalolepis*			
	Bet Dagan	Rehovot	Giv'at Brenner	Ness Ziyyona	Ma'agan Mikhael	Giv'at Hayyim	Hulda	Ramat Yishay	Kahal	Korazim
HYMENOPTERA										
Braconidae										
Agathus umbellatarum	-	9	-	-	-	-	-	-	-	-
Bracon uricator	3	7	-	-	-	-	-	-	-	-
Bracon leptus	48	116	73	128	7	39	108	-	-	-
Microchelonus sp.	-	4	9	6	-	9	-	-	-	-
Ichneumonidae										
Exeristes roborator	6	5	7	2	-	-	-	-	-	-
Temelucha sp.	5	5	17	16	-	-	-	-	-	5
Eurytomidae										
Eurytoma 3-4 spp.	112	210	31	69	-	3	390	-	-	3
Eulophidae										
Tetrastichus sp.	17	17	24	70	5	19	-	-	-	11
Eupelmidae										
Gen. 2 spp.	14	9	24	21	-	-	-	-	-	-
Orymidae										
Orymus sp	46	174	15	93	-	49	-	-	-	-
Pteromalidae										
Gen.sp. & Cyrtoptyx ?latipes	24	18	16	21	28	-	-	-	-	16
Torymidae										
Gen. 3-4 spp.	16	12	8	9	-	4	34	-	-	-
Cynipidae										
Gen. 2-3 spp.	18	122	3	20	-	9	-	-	-	-

Acknowledgements
We thank acting director Dr. Dan Strickman of the USDA-ARS European Biological Control Laboratory for financing this work.

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Host Specificity Testing of *Citrostichus phyllocnistoides* (Narayanan) a Parasitoid of the Citrus Leafminer, *Phyllocnistis citrella* Stainton in California.

Robert V. Dowell and Kris Godfrey

The citrus leafminer, *Phyllocnistis citrella* Stainton, is an exotic moth that has become established in California. The citrus leafminer is becoming an important pest of several citrus varieties including lemons and thin skinned mandarin-type fruit. Growers are finding citrus leafminer difficult to control, especially in northern California. Native leafminer parasitoids are not exerting sufficient control of citrus leafminer to prevent insecticide sprays. The parasitoid *Citrostichus phyllocnistoides* (Narayanan) has been shown to be effective against citrus leafminer in other areas with climates similar to California. The Biological Control Program has a long-term goal of releasing *C. phyllocnistoides* to reduce population densities of leafminer and reduce control costs for growers.

As the first step in achieving this goal, we will start evaluating the safety of this parasitoid introduction by testing the ability of *C. phyllocnistoides* to attack and complete larval development on native and other beneficial non-target moths related to the citrus leafminer. Host specificity data are required by the USDA and state regulators before they will consider allowing the release of the parasitoid in California. This parasitoid has been released in Florida. The Florida Department of Agriculture and Consumer Services has a colony of the parasitoid and they are willing to supply us with parasitoids for the tests.

Previous Laboratory Work

Australian scientists tested the ability of *C. phyllocnistoides* to attack 19 species of potential leafmining or gall forming hosts in a series of choice tests. The test insects comprised 11 Lepidoptera, including one species in the same genus as the citrus leafminer, four Diptera and three Coleoptera. *C. phyllocnistoides* did not attack any of these potential alternate hosts.

Previous Field Work

Researchers have examined the occurrence of *C. phyllocnistoides* in field collected leafminers and gall forming insects, besides the citrus leafminer, in and around citrus orchards. In one European study, 31 species of phytophagous leaf mining insects were reared including one Hymenoptera, 10 Diptera and 20 Lepidoptera including 11 Gracillariidae of which four were from the same genus (*Phyllocnistis*), the citrus leafminer. They reared over 500 parasitoids from these insects, four of which were *C. phyllocnistoides* (<0.8% of the total parasitoids reared). A male and a female *C. phyllocnistoides* each were reared from an unidentified species of Nepticulidae in Sicily and a *Stigmella* sp. (Nepticulidae) in Jordan. They described the use of alternative hosts as low. They also noted a recovery from a psyllid gall former (*Trioza obsoleta*).

Italian researchers collected samples of non-citrus plants from orchards in 2002-2003. They reared no *C. phyllocnistoides* in 2002. In 2003, they reared *C. phyllocnistoides* from the moth *Cosmopterix pulcherimella* (Cosmopterigidae) and a *Liriomyza* sp. fly. They concluded that the rate of parasitization of these non-target insects was "so low (8.3% and 3.3% for *C. phyllocnistoides* on *C. pulcherimella* and *Liriomyza* sp., respectively) that any detrimental effect on both native leafminers and autochthonous parasitoid populations can be excluded." Neither the laboratory nor the field studies of at least 48 species of potential hosts found any systematic movement of *C. phyllocnistoides* onto hosts other than the citrus leafminer.

Effect of UV Irradiation on Hatching of Light Brown Apple Moth Eggs

Nada Carruthers and William Roltsch

Trichogramma egg parasitoids are under evaluation for use in the control of the light brown apple moth, *Epiphyas postvittana* (LBAM). Currently, eggs of several other species of Lepidoptera are used to maintain laboratory colonies of *Trichogramma*. The objective of this study is to find a treatment for LBAM eggs that prevents hatch. Inhibited eggs are needed since larvae derived from unparasitized eggs interfere with the rearing of egg parasitoids. In addition to enabling laboratory studies on egg parasitoids, development of non-hatching LBAM eggs may facilitate field population studies of LBAM egg parasitoids.

Effects of UV irradiaton on LBAM eggs

LBAM eggs were obtained from the USDA-APHIS Albany laboratory colony. All test eggs were 24 hours old and counted under a stereo microscope. The length of exposure and distance to the light source were tested at room temperature (22±2ºC). UV exposure treatments were: 0, 45, 90 and 135 minutes. A short wave UV 256 nm 8W lamp was kept either 26 or 13 cm away from exposed eggs. The sample size was n=100 eggs per treatment. The number of replicates was five for 26cm source distance and three for 13cm source distance. After irradiation, eggs from each sample were placed in a petri dish lined with wet filter paper and sealed with para-film. Eggs were incubated at 25º C in an environmental chamber. After 12 days, the eggs were recounted and the hatch rate was determined.

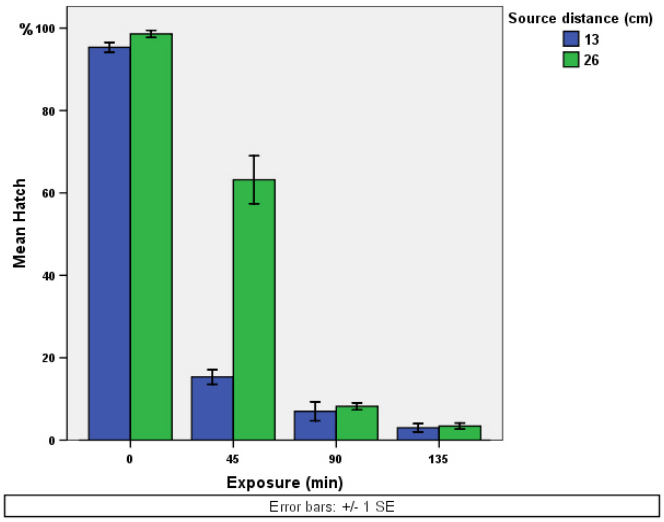


Figure 1. Effect of duration of UV light exposure and distance of light source on embryogenesis of LBAM.

There was strong negative correlation between egg hatch and duration of UV light exposure (Pearson product moment correlation coefficient test $r=-0.898$, $n=31$, $p<0.0005$)(Figure 1). The length of exposure significantly affected egg hatching potential. Light source distance did not significantly affect hatching at the higher durations of exposure (90 and 135 min.). We did not prevent 100% egg hatch on any of the applied treatments.

In a subsequent test, exposure was extended to 180 and 240 min. to reduce egg hatch. The light source distance of 13 cm was accepted as standard. Extended exposure time did not further decrease hatching rate (Figure 2). The only explanation for this trend, where increasing exposure time (>90 min.) does not translate to decreased hatching is that LBAM tend to lay eggs in a layered fashion and that lower layers of eggs do not receive enough UV radiation to prevent their hatching.

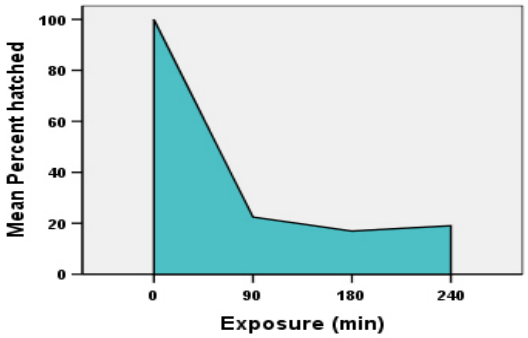


Figure 2. Effect of extended UV light exposure on hatching of LBAM eggs.

The fate of larvae that hatched from irradiated eggs was addressed in a subsequent study, in which hatched larvae were followed to eclosion (Figure 3). Groups of egg masses were exposed to 0, 90, 180, and 240 minutes. After exposure, egg masses were placed on artificial diet. Diet used for this study was originally developed for pink boll worm and it was obtained from a mass rearing facility in Phoenix, AZ. Diet containers with eggs were incubated in an environmental chamber at 25ºC and 16L:8D light cycle. After 45 days of incubation, the diet containers were opened and an adult count was taken. Applied irradiation did not prevent hatched larvae from completing development (Figure 3) and no malformations were observed on collected adults.

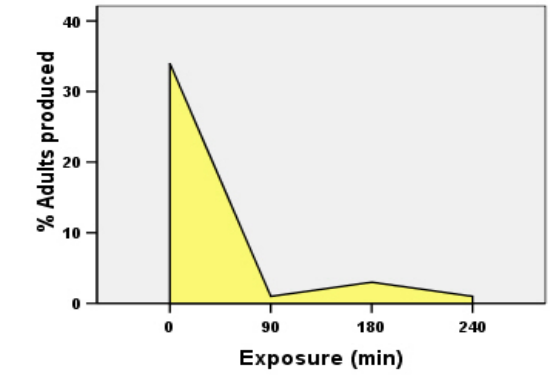


Figure 3. Effect of UV irradiation of LBAM eggs on adult production.

Field test of UV treated sentinel eggs

On three dates, sentinel eggs were placed on ornamental plants in Santa Cruz. The objective was to compare the level of parasitism sustained by UV treated versus untreated LBAM eggs under field conditions. Plastic egg cards (1x2.5 cm) containing egg masses (30-80 eggs ea.) previously laid within 24 hr. on clear plastic, disposable food cups were UV treated for 90 min. as stated above. Egg cards (40 per treatment) were randomly stapled on host plants in the field and collected after 67 degree days (celcius) had past. Data reported herein represent the portion of egg cards containing parasitism.

Results to date suggest that while parasitism was not significantly negatively affected by UV treatment (perhaps due to limited testing and high variability), usage of treated eggs is likely to influence quantification of infield parasite activity (Table 1). This conclusion is also supported by the expansion of the study during the third trial to include parasitism on *Leucodendron*, in which 40 egg cards were placed on *Leucodentron* plants at the same site. During past field

monitoring studies at this site using untreated LBAM eggs, percent parasitism was comparable between manzanita and *Leucodendron*. Results may have been affected by overall *Trichogramma* densities in the field during each test, and species composition of the *Trichogramma* population. The latter information is not available at the time this report was prepared.

Table 1. Percent of egg cards with parasitized eggs.

Test Dates 2010	Plant		
	Manzanita		*Leucodendron*
	UV Treated	Non-Treated	Non Treated
21-29 July	81%	87	-
15-22 September	56	72	-
20-28 October	27	70	64
Back transformed means	55.2	76.8	-
Paired comparisons test	t value = -2.12 Pr> t 0.169	(Test based on arcsin sqrt transformed percentages)	

Cold Storage Studies of Oblique Banded Leaf Roller Eggs and Pupae, and *Ephestia kuehniella* Eggs

William J. Roltsch and Harmit K. Cheema

As part of the light brown apple moth project, colonies of several species of *Trichogramma* are maintained in the laboratory using eggs of the oblique banded leafroller (OBLR), *Choristoneura rosaceana,* and the Mediterranean flour moth, *Ephestia kuehniella*. Eggs of OBLR are produced in laboratory cultures. Eggs of *E. kuehniella* are obtained from a commercial insectary, having previously been UV treated to prevent development to the voracious larval stage. Eggs of both species are often held for varying lengths of time until they are needed for *Trichogramma* cultures. In addition, pupae of OBLR are held in cold storage until the moths are needed for egg production. For the purpose of refining our host and parasitoid rearing practices, the following studies examined the impact of several temperature regimes and storage durations on egg and pupal longevity and suitability for parasitism.

Storage Temperature Impact on OBLR Egg Hatch

A seven day cold storage event was studied at 41 and 54° F. Treatments include: 41° F (39-43°F) 85% RH, 54° F (52-56°F) 77% RH, and a 70° F control (69-71° F) 68% RH. Egg masses were placed in glass vials, then plugged with cotton. Vials were place in cold storage treatment chambers with no lighting for 7 days. The control was located on a laboratory shelf with 40 watt overhead florescent lighting, 16L/8D. All treatments consisted of eggs held in tightly sealed food storage boxes with humidity created by the use of water saturated rock salt in a 4 oz cup. Lab records indicate that RH values have a range of ± 5%.

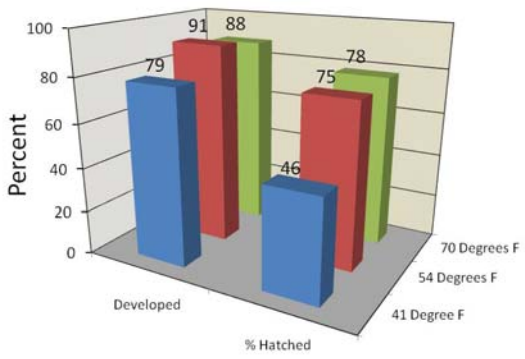


Figure 1. Effect of cold storage temperatures on OBLR egg viability. Percent of all eggs that hatched, and percent unhatched eggs exhibiting development.

Each egg mass consisted of 82-150 eggs. Each treatment included four egg masses laid within 48h. The cold storage treatments were held at the specified temperature for 7 days. Subsequently, eggs masses of these treatments were relocated on the same shelf as the control for completion of development. Eclosion was recorded after being held for 14 days, as was number of unhatched eggs exhibiting development.

Mean overall egg hatch was only 46% (SE ± 10.2) at 41° F compared with eggs stored at 54° F and the control (75%: SE ± 6.9%, 78%: SE ± 6.8% respectively) (Figure 1). The number of unhatched eggs showing some degree of development were approximately 10% less for the 41° F treatment.

Storage Temperature Impact on OBLR Pupal Survivorship

A 10 day pupal storage event was studied at 45° F and 54° F; two commonly used temperatures for holding live insects. Treatments included: 1) 45° F in 4 oz. plastic cup with lid; 2) 54° F in plastic cup with lid (both 1 and 2 held in environmental chambers with ambient humidity of 40-55% RH); 3) 45°F at 80% RH; 4) 54°F at 75% RH; and 5) a control consisting of pupae placed in plastic cup with lid and held at ambient room conditions (approx. 70° F, and 55% humidity). Treatments with elevated humidity (i.e., 3 and 4) were held in tightly sealed food storage boxes with humidity maintained by using water saturated rock salt.

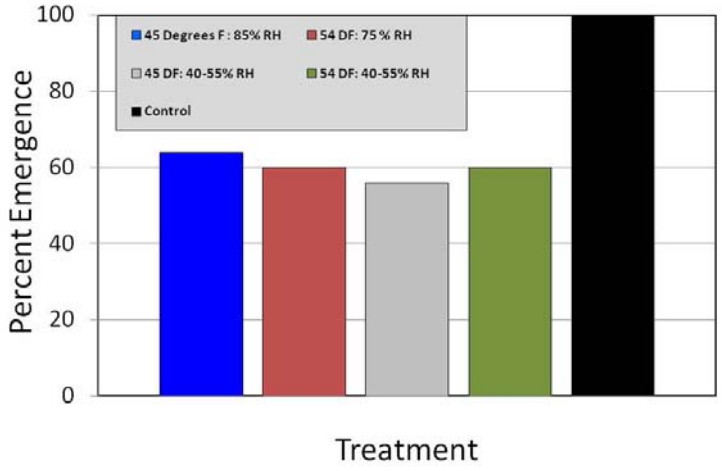


Figure 2. Successful emergence of moths in each treatment.

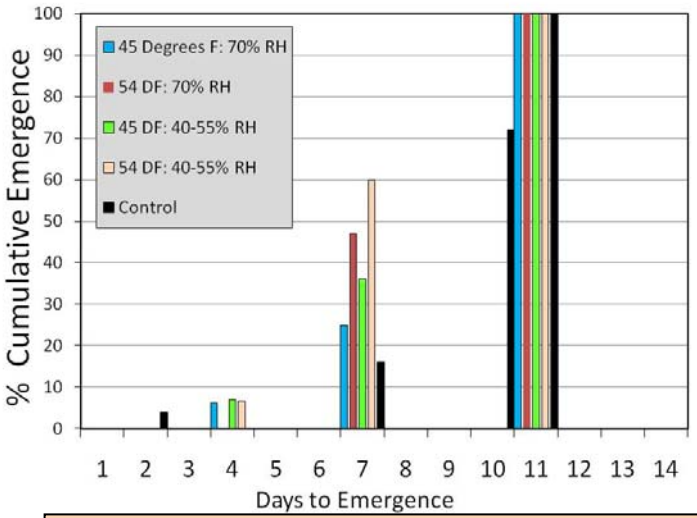


Figure 3. Emergence pattern of pupae following placement at room temperature.

Twenty five freshly collected pupae (est., within 72 hrs. old) were used in each of the five treatments. All treatments except the control were held at specified cold storage temperatures for 10 days. Subsequently, pupae were placed in cups with additional paper substrate for moths to crawl onto, and held in conditions equivalent to the control. Emergence was recorded every three days following placement in emergence cage.

Percent emergence did not differ between the two storage temperatures, however, storage did cause approximately a 40% reduction in emergence compared to the control (i.e., no storage period) (Figure 2). Number of days to emergence, once placed at room temperature, was similar among treatments, with complete emergence of each group within 11 days (Figure 3).

Impact of *Ephestia* Egg Storage Duration on *Trichogramma* Parasitism

Ephestia kuehniella eggs used for rearing several species of *Trichogramma* are irradiated by the commercial supplier using UV light. Although eggs may show signs of development with this treatment, egg hatch is very rare. This allows for the rearing of parasitoids without the interference of caterpillars hatching from unparasitized eggs. We have been advised to use the eggs within a week of receiving them. The following study examines the comparative usefulness of eggs that are estimated to be up to four weeks old.

Eggs were held in a refrigerator at 37 – 44° F, at approx. 80% RH when received. At the time of setup, egg treatments were estimated to be the following ages: three to seven, 17-21, and 24-28 days old. For each treatment age, more than 500 eggs were attached to each of four, 4X12 mm paper cards using double-sided tape. One card per treatment was attached to a larger piece of paper in combination with individual cards of the other two treatments; with each of the three cards radiating out from the center of the larger piece of paper. Four such replicates were created and each set was placed in a separate 500ml glass bottle containing several hundred adult *T. deion* wasps for two days. Subsequently, cards were removed and placed in empty bottles to complete development, at approximately 72° F and 70% RH. After several weeks, counts of parasitized and unparasitized eggs were made on three, 9 mm^2 portions of each card.

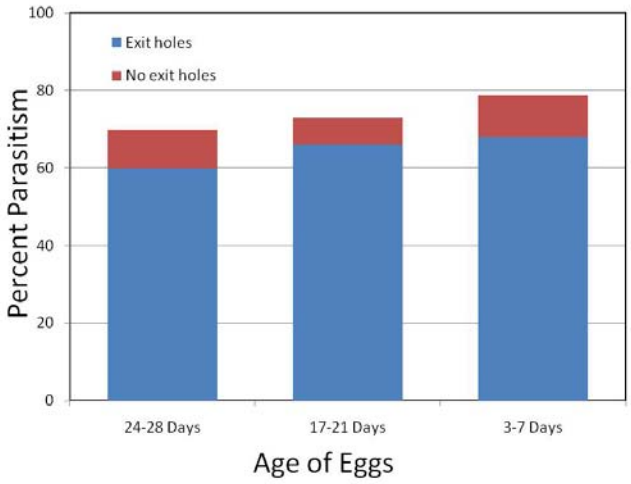


Figure 4. Percent parasitism by *T. deion of Ephestia kuehniella* eggs held in storage for varying lengths of time. Exit hole data represents emerged parasites, typically 1 per *Ephestia* egg.

The production of both total number of parasitized *Ephestia* eggs and emerged parasites (noted by exit holes) declined very little over approximately four weeks of cold storage. The standard error values were low; less than 6% in all cases in Figure 4.

Establishment of Giant Whitefly Parasitoids in California

Charles H. Pickett, Stan Maggi[1], Marc Lea[2], and Marypat Stadtherr

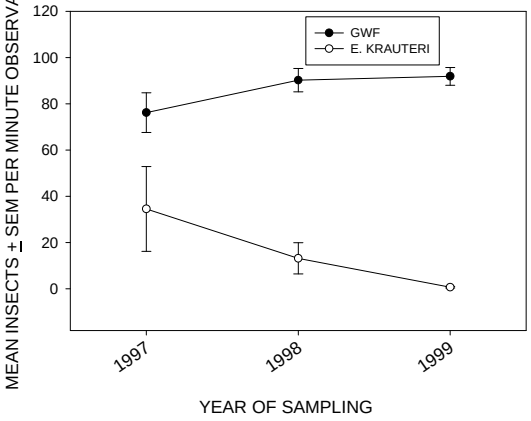
The giant whitefly(GWF), *Aleurodicus dugesii*, Cockerell was first discovered in San Diego on October 15, 1992. It has been previously reported from north central Mexico (Zacateca) and the southern tip of Baja California (Gill, pers. comm.). The giant whitefly has also invaded and established populations in eastern Texas, Florida, Louisiana, and Hawaii. The original finds were mainly from hibiscus but the whitefly spread to a broad range of subtropical perennial trees and shrubs in southern California, including Xylosma, palm, apricot, bird-of-paradise, and morning glory. It also attacks avocado and citrus, two important agricultural crops in San Diego County. This whitefly poses a serious health problem to the general public and a potential economic problem to California agriculture. The San Diego Zoo for many years actively controlled dense pockets of this pest throughout their park using high pressure water and leaf removal. The nymphal stages produce long waxy hairs, up to six inches long that can break off and float in the air, carrying honeydew with it. Leaves with high densities of giant whitefly are flocked with this white material (Figure 1). Sooty mold eventually builds up on leaves reducing their photosynthetic capability.

Figure 1. Giant whitefly on Xylosma, Santa Clara.

Three parasitoids were released in southern California during the mid-1990's for control of giant whitefly. *Entedononecremnus krauteri* was imported into San Diego in 1995 (by Pickett and Rose), while *Idioporus affinis* and *Encarsiella noyseii* were imported in 1996 by the University of California, Riverside (Hoddle and Headrick). Today in southern California, *I. affinis* is the dominant parasitoid found attacking giant whitefly.

The impact of *E. krauteri* releases at the San Diego Zoo was tracked for three years, from 1997 to 1999 (Figure 2). Although their numbers during the first summer of releases increased, they were not sustained. By the end of 1999, *E. krauteri* almost disappeared and GWF densities were the same as when we first started recording data, about 90 adults per minute. Apparently they were not preadapted to the climate in San Diego County, or just could not compete with *I. affinis*. Ten years later, first in 2007 then again in 2010, limited observations were made at the same location of the San Diego Zoo. Five adult GWF

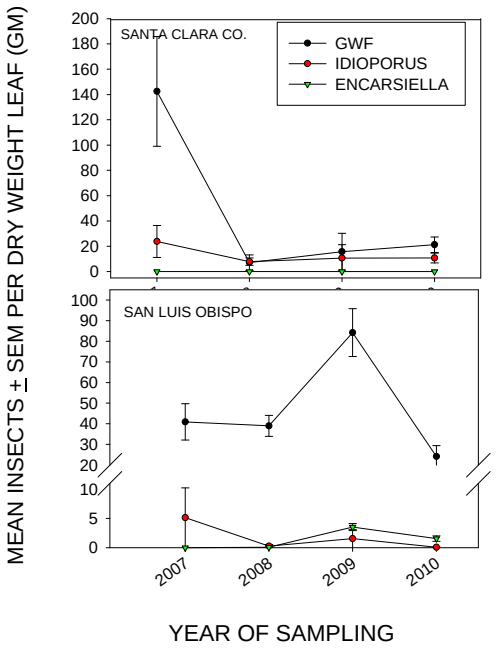
FIG. 2. Seasonal averages for giant whitefly on hibiscus, San Diego Zoo.



were found on hibiscus in a single 10 minute observation in December 2007, while in December 2010 about 10 adults were seen per minute, averaged over three sampling events in the same region of the zoo. Both observations were a small fraction of the original infestation levels. On both occasions, *I. affinis* were seen in association with these whiteflies. The hibiscus now, compared to back in the late 1990's, appears almost whitefly free.

Further north in the state, the giant whitefly was found in 2007 in high numbers in Santa Clara and San Luis Obispo counties. Having been contacted by these counties, the Biological Control Program of CDFA with County staff began monitoring GWF populations for extant parasitoids with the intention of importing from southern California any parasitoids absent from these regions. Insect populations were monitored using a single host plant known to be highly susceptible to GWF, Xylosma. Field collected Xylosma samples were placed in paper cans, transported to the Program's laboratory in Sacramento and allowed to incubate in a controlled environmental chamber for two months. On the first sampling date, in 2007, high numbers of GWF but low numbers of *I. affinis* were recorded both in San Luis Obispo and Santa Clara County. In 2008, *Encarsiella noyesii* was found in San Luis Obispo and it was later learned that intentional, planned releases of both these parasitoids had been made in 2006 (D. Headrickson, pers. comm.). We also picked up small numbers in the latter location of what is probably *Encarsia hispida*. Also during 2008, *I. affinis* was found in high numbers at several sites in Santa Clara County, with roughly equal numbers of whitefly and parasitoids. Interestingly, numbers of *I. affinis* in Santa Clara County, where *E. noyesii* has yet to establish, are much higher than have been recorded in the city of San Luis Obispo.

Fig. 3. Seasonal average densities of GWF infesting Xylosma and introduced parasitoids Santa Clara Co. and San Luis Obispo, 2007 to 2010.



The initial high numbers of GWF first recorded in Santa Clara County during 2007 have not returned and most likely *I. affinis* had recently invaded the region along with GWF. We found just a few parasitoids at the beginning of summer and much higher densities towards the end. Calls to the Santa Clara County office from private homeowners have also dropped dramatically since 2007. Numbers of GWF in San Luis Obispo dropped significantly from the high numbers recorded in 2009. Additional sampling will be needed to determine the long term fate of GWF in these locations.

[1]Santa Clara Agricultural Commissioner's Office
[2]San Luis Obispo County Department of Agriculture

Parasitoids Attacking Cotton Aphid in Pomegranates and Citrus in Tulare County

Kris Godfrey, Janine Lee[1], and Beth Grafton-Cardwell[1]

The cotton aphid, *Aphis gossypii* Glover, is a polyphagous insect pest that can vector one of the most important pathogens of citrus, citrus tristeza virus (CTV). In eastern Tulare County, the number of CTV-infected trees has increased significantly over the past five years, hindering the production of virus-free budwood at the University of California Lindcove Research and Extension Center (LREC), used by citrus nurseries throughout the state to produce citrus trees. Concomitant with the increase in CTV-infected trees has been a significant increase in the acreage of pomegranate around LREC. Pomegranate has been shown to be an overwintering host for the cotton aphid on which a sexual generation of the aphid will occur (Figure 1). The result of this sexual generation is a large number of alate or winged aphids ready to disperse out of pomegranates into citrus during the spring flush in citrus, a time when titers of CTV are at the highest in citrus. Reduction of the density of alate aphids in the spring will result in a slowing of the spread of CTV. Management programs for cotton aphid in pomegranates are currently being developed, and biological control is the basis for most of these programs. Prior to releasing additional parasitoids in pomegranate orchards in future years, a survey was conducted to determine which parasitoid species are present in selected pomegranate orchards.

Figure 1. Overwintering cotton aphids on stems and leaves of pomegranates in eastern Tulare County.

The survey was conducted at six sites around LREC that had both pomegranates and citrus. Sites 1, 4, 5, and 6 were managed using insecticides, but had differing numbers of aphids. Site 1 had high numbers of aphids, whereas Sites 4-6 had low numbers of aphids. The differences in aphid numbers at these four sites was most likely the result of how and when the insecticides were applied at each site. Sites 2 and 3 were managed using methods compliant with certified organic production (e.g., oils, parasitoids, etc.). Sampling of the sites began in May 2010 and is continuing. Results in this report include all samples taken between May and October 2010. For each sampling visit at each site, 10 flushes on each of 20 randomly selected trees were inspected, and the percent of infested flushes on the tree, estimated. To collect aphids, 5 twigs in heavily infested sites and 10 infested twigs in lightly infested sites were collected and returned to the laboratory. During periods of high aphid density, collections were made every two weeks. At times of low aphid density, collections were made once a month. The twigs are examined and the number of apparently healthy aphids, mummified aphids, emerged mummies, and "fuzzy" aphids (aphids infected with a fungus) were recorded. Intact mummies were placed

in gelatin capsules to allow for parasitoids to emerge. Another collection of up to 100 aphids were held in a container in the lab and inspected periodically for mummy formation and/or the emergence of parasitoid adults. The mummies and parasitoid adults were collected and identified.

Primary and secondary parasitoids were recovered at all sites (Table 1). Sites 1, 3, and 5 produced the most parasitoids, while Sites 2, 4, and 6 produced few parasitoids due to low aphid numbers. The proportion of primary to secondary parasitoids varied through time of year in a pattern typical for cotton aphid parasitoids in other systems. The *Aphelinus* sp. parasitoids recovered were sent to specialists for identification. The parasitoids recovered belonged to the *Aphelinus varipes* complex, but had morphological characteristics intermittent between *Aphelinus atriplicis* and *Aphelinus albipodus*. However, the parasitoids recovered were identical to the parasitoids released as *Aphelinus* near *paramali* in these blocks in 2007 and 2008 (Dr. Greg Evans, personal communication). Molecular analysis of the DNA from these specimens is currently underway to clarify the identity of the parasitoids released and recovered. No evidence of fungal infection was found in any of the aphids collected.

Table 1. The number and identity of parasitoids recovered from aphid sampling in Tulare County from May through October 2010.[a]

Date	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
May 6 - 11	1 *Lysiphlebus* 1 Charipidae	8 Charipidae	2 *Lysiphlebus* 3 Charipidae 5 Pteromalidae	1 Charipidae	1 Charipidae	1 Charipidae
May 21 - 24	1 *Aphelinus* sp. 1 *Lysiphlebus*	13 *Lysiphlebus*	1 *Lysiphlebus* 5 Charipidae	-	-	-
June 4	22 *Lysiphlebus* 10 Charipidae 1 Pteromalidae	1 *Lysiphlebus*	6 *Lysiphlebus* 4 Charipidae 2 Pteromalidae	-	-	-
June 18	4 *Lysiphlebus* 9 Charipidae 5 Pteromalidae	-	-	-	-	-
July 2 - 6	3 Pteromalidae	-	-	-	-	-
July 30	1 *Aphelinus* sp.	-	1 *Aphelinus* sp.	-	-	-
August 13	3 *Aphelinus* sp.	-	1 *Aphelinus* sp.	-	-	-
September 10	11 *Aphelinus* sp. 7 *Lysiphlebus*	-	1 *Aphelinus* sp.	-	91 *Lysiphlebus* 3 *Aphidius*	-
September 28	-	3 *Lysiphlebus*	-	-	5 *Lysiphlebus* 7 Pteromalidae	-
October 14	1 *Lysiphlebus*	-	-	-	3 *Lysiphlebus*	-

[a]*Lysiphlebus*, *Aphidius*, and *Aphelinus* sp. are primary parasitoids. Charipidae and Pteromalidae are secondary parasitoids. The identity of *Aphelinus* sp. is pending the results of DNA analysis, but the species belongs to the *Aphelinus varipes* complex. (-) none detected or no aphids found in sample.

[1]Lindcove Research and Extension Center, Exeter, California.

Phenology of Olive Tree Cultivars at the USDA-ARS Wolfskill Repository

Daniel Wisheropp and Charles H. Pickett

One of the most serious challenges to establishment of new parasitoids for control of the olive fruit fly, *Bactrocera oleae* (Diptera: Tephritidae) is host continuity. From April to July, few if any fruit, and thus fly larvae, remain on trees and are available to recently released parasitoids. An adult parasitoid must find the last remaining infested fruit in a region, be capable of surviving for several months as an adult, or be able to develop on alternate hosts. Parasitoids of high host specificity preclude the latter. To bridge this gap, we are suggesting the use of a mix of olive tree cultivars, including some capable of carrying fruit on the tree late into the spring.

The USDA-ARS repository located at the University of California Wolfskill Experiment Station has over 100 cultivars of olive collected from around the world. Based on field observations and harvesting records from the USDA-ARS, seven cultivars were chosen for monitoring, including the wild subspecies of olive tree, *Olea europaea cuspidata*. The chosen trees were spread between an old and new orchard at the Wolfskill Experiment station. Up to seven individuals for each cultivar were selected. The sampling began in late summer 2009 after the fruit began to set and continued monthly through spring until all fruit had fallen. Observations were repeated beginning mid-summer 2010. A ripeness scale was created to record fruit maturation based on the color of the majority of fruit for a given tree (Table 1). The ripeness scores were averaged monthly to give a fruit maturity value for each cultivar (Figure 1). In addition, the percentage of trees for each cultivar still bearing fruit each month was calculated.

Figure 1. Olive cultivar phenology, 2009-11, UC Wolfskill Exp. Station. N= 1-7, columns =fruit ripeness; solid lines =percentage of trees bearing fruit.

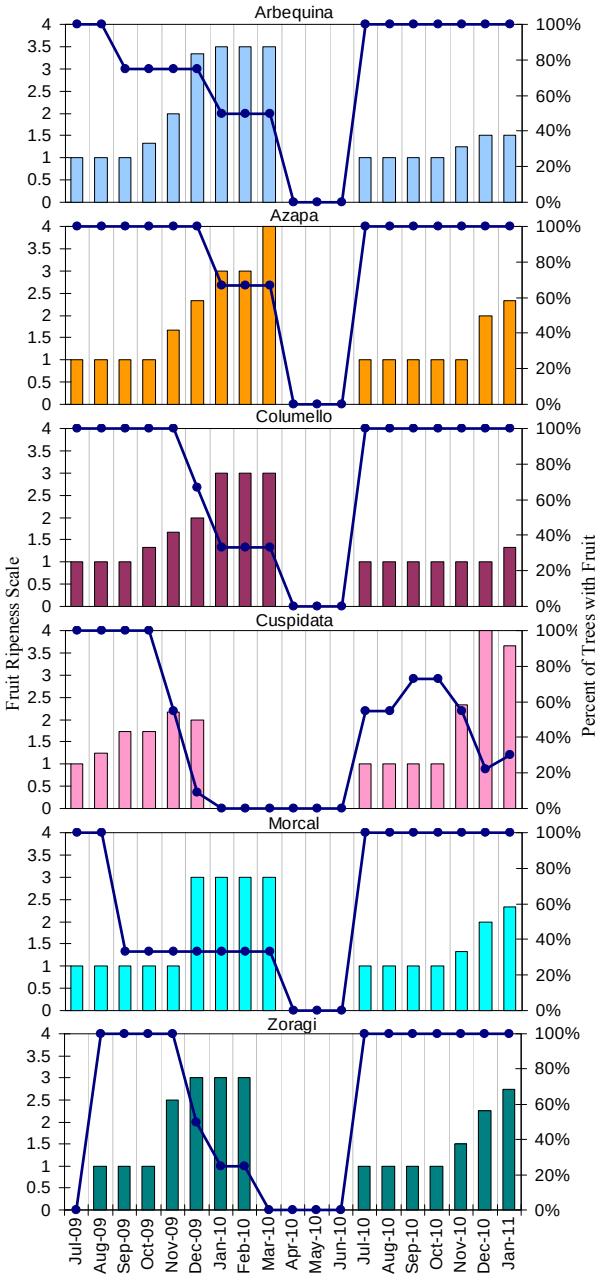


Table 1. Scale for scoring fruit ripeness.

Scale	Color
0	No fruit or unharvestable
1	Green
2	Green-purple
3	Purple
4	Black

There was a surprising lack of consistency from one year to the next in cultivar maturation. In 2009, the Columello variety developed at about the same rate as other varieties, but so far during the 2010-2011 season, it is the slowest to ripen. By January of 2009, *Olea europaea cuspidata* had dropped all its fruit, yet during January 2011 it retains much of the fruit. The most important trait we are looking for is late maturing fruit. During the first season, 2009 to 2010, four of the six cultivars still had fruit in March 2010, but all had dropped them by April.

Releases of Olive Fruit Fly Parasitoids

Charles H. Pickett, Daniel Wisheropp, Xin-geng Wang[1], Kent Daane[2], Yael Argov[3], Diego Nieto[4], Marshall Johnson[4], and Kim Hoelmer[5]

Beginning August 2010, CDFA and cooperators at the University of California, Berkeley and University of California, Riverside - Kearney Field Station, made releases of two braconid olive fly parasitoids, *Psytallia lounsburyi* (ex. Mt. Kenya) and *P. concolor* (ex. Namibia). Small numbers of parasitoids had been released from 2006 to 2008. Since that time, additional parasitoids have been produced under contract for release in California by the Israel Cohen Biological Control Institute (Figure 1).

Figure 1. Dr. Yael Argov, Israel Cohen Biological Control Institute, Beit Dagan, Israel.

Psytallia concolor was also produced for us by the USDA APHIS Moscamed group in Guatemala this last year. Together, both organizations were able to rear a much higher number of *P. concolor* and *P. lounsburyi* than has been done in the past by ourselves. A total of 22,671 *P. concolor* and 9,454 *P. lounsburyi* were released across San Luis Obispo, Solano, Sonoma and Yolo counties, including two new counties, San Diego and San Mateo, in summer/fall 2010 (Table 1).

Adult parasitoids were released directly into olive trees or into field cages enclosing branches on the same trees. This last year we made recoveries of *P. concolor* (open releases) at three locations, one more than last year, and for the first time we made within-season recoveries of *P. lounsburyi* from our new release site on the Cañada Community College Campus near

Redwood City, and at the UC Davis release site (Table 2). Monitoring of release sites will continue, as well as additional releases of these and more recently permitted parasitoids.

Table 1. Releases of *Psyttalia* spp. in California in 2010.

Release Date	Species	Origin	Site	Latitude (decimal degrees)	Longitude (decimal degrees)	Type	Number released
8/24/2010	*P. concolor*	Namibia	San Diego, San Diego Co.	N 32.75921	W 117.19449	Open	1000
8/24/2010	*P. lounsburyi*	Kenya	San Diego, San Diego Co.	N 32.75922	W 117.19450	Open	1274
9/9/2010	*P. concolor*	Namibia	Site 1, San Luis Obispo Co.	N 35.191389	W 120.70722	Open	5800
9/17/2010	*P. concolor*	Namibia	San Diego, San Diego Co.	N 32.75921	W 117.19449	Open	3100
9/17/2010	*P. lounsburyi*	Kenya	San Diego, San Diego Co.	N 32.75922	W 117.19450	Open	800
9/21/2010	*P. concolor*	Namibia	UC Davis, Yolo Co.	N 38.53985	W 121.76504	Open	2281
9/21/2010	*P. lounsburyi*	Kenya	UC Davis, Yolo Co.	N 38.53985	W 121.76504	Open	760
9/27/2010	*P. concolor*	Namibia	Cañada College, San Mateo Co.	N 37.44925	W 122.26667	Open	750
10/11/2010	*P. concolor*	Namibia	Site 2, San Luis Obispo Co.	N 35.19000	W 120.70916	Open	1600
10/28/2010	*P. concolor*	Namibia	Cañada College, San Mateo Co.	N 37.44925	W 122.26667	Open	4860
10/28/2010	*P. lounsburyi*	Kenya	Cañada College, San Mateo Co.	N 37.44925	W 122.26667	Open	920
10/28/2010	*P. concolor*	Namibia	Cañada College, San Mateo Co.	N 37.44925	W 122.26667	Caged	600
10/28/2010	*P. lounsburyi*	Kenya	Cañada College, San Mateo Co.	N 37.44925	W 122.26667	Caged	600
11/19/2010	*P. concolor*	Namibia	UC Davis, Yolo Co.	N 38.53985	W 121.76504	Open	2680
11/19/2010	*P. lounsburyi*	Kenya	UC Davis, Yolo Co.	N 38.53985	W 121.76504	Open	4100
11/22/2010	*P. lounsburyi*	Kenya	Site 3, San Luis Obispo Co.	N 35.2975	W 120.65388	Open	500
11/22/2010	*P. lounsburyi*	South	Site 3, San Luis Obispo Co.	N 35.2976	W 120.65389	Open	500

Table 2. Recoveries of *Psyttalia* spp. released in 2010.

Date of Collection	Species	Origin	Site	Latitude (decimal degrees)	Longitude (decimal degrees)	Type	Number recovered
9/9/2010	*P. concolor*	Namibia	Site 1, San Luis Obispo Co.	N 35.191389	W 120.70722	Open	43
10/10/2010	*P. concolor*	Namibia	Site 2, San Luis Obispo Co.	N 35.19000	W 120.70916	Open	5
10/26/2010	*P. concolor*	Namibia	UC Davis, Yolo Co.	N 38.53985	W 121.76504	Open	2
10/28/2010	*P. concolor*	Namibia	Cañada College, San Mateo Co.	N 37.44925	W 122.26667	Open	21
10/28/2010	*P. concolor*	Namibia	Cañada College, San Mateo Co.	N 37.44925	W 122.26667	Caged	34
10/28/2010	*P. lounsburyi*	Kenya	Cañada College, San Mateo Co.	N 37.44925	W 122.26667	Open	2
10/28/2010	*P. lounsburyi*	Kenya	Cañada College, San Mateo Co.	N 37.44925	W 122.26667	Caged	51
11/18/2010	*P. concolor*	Namibia	UC Davis, Yolo Co.	N 38.53985	W 121.76504	Open	5
12/15/2010	*P. concolor*	Namibia	UC Davis, Yolo Co.	N 38.53985	W 121.76504	Caged	3

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Egg Parasitoids of Diaprepes Root Weevil

Loretta Bates[1], James Bethke[1], Gary Bender[1], Joseph Morse[2], Jorge Peňa[3], and Kris Godfrey

Diaprepes root weevil, *Diaprepes abbreviatus*, is a polyphagous weevil with a broad host range and is considered a major insect pest of citrus, woody ornamental plantings, and ornamental plant nurseries. The incompletely described host range includes avocados, stone fruit, grapes, and a number of landscape plants unique to California. It was found infesting parts of Orange, Los Angeles, and San Diego counties in 2005 and 2006. In 2006, the California Department of Food and Agriculture began an eradication program in the known infested areas of these three counties. Insecticides were a core component of the eradication program, however, the more effective insecticides had limited registration labels and could not be used in some of the treatment areas. In July 2008, the eradication program ended with a loss of funding. Research on biological control was initiated in 2007 to determine if egg predators or parasitoids could be used as a part of the management program and has continued through 2010.

The wasp *Aprostocetus vaquitarum* was the first natural enemy released in San Diego County because it is known to impart significant mortality to Diaprepes populations in southern Florida, and a laboratory colony is maintained at the University of Florida, Tropical Research and Education Center. This wasp is actually a predator, rather than a parasitoid. The female wasp places her eggs within the Diaprepes egg mass. The eggs hatch, and the wasp larvae begin to feed externally on the Diaprepes eggs within the mass. Each wasp larva requires more than one Diaprepes egg to complete development. The wasp larva eventually pupates within the Diaprepes egg mass. Shipments of *A. vaquitarum* were made to the University of California – Riverside Quarantine Facility from Florida beginning in 2006. Field releases were initiated in October 2007 and continued through 2010. In 2010, 1,742 *A. vaquitarum* adults were released at six sites in five cities in San Diego, Orange, and Los Angeles counties from March – September. Releases were made at known infested sites that were not treated with insecticides. Monitoring of the release sites to determine the success of the releases was conducted by searching for Diaprepes egg masses. Sites were searched from June 15 through September 28, 2010, and 158 egg masses were found. No *A. vaquitarum* parasitoids or any other species of parasitoids were recovered from these egg masses. Monitoring will continue in 2011 at release sites.

One potential explanation for the apparent lack of establishment was the effect of the colder climate in southern California compared to Florida where the parasitoid has been successful. Sleeve cage trials were also conducted in 2010 at a heavily infested site in Orange County to determine if *A. vaquitarum* could survive the climatic conditions in southern California. In these trials, sleeve cages were placed around new growth on caliandra (an ornamental host plant of Diaprepes) branches. Seven to nine field-collected Diaprepes weevils were placed inside each sleeve cage and allowed to feed and oviposit for three to four days. The weevils were then removed, the number of egg masses per cage recorded, and two to three adult *A. vaquitarum* were placed in each cage. The contents of each cage were examined for the presence of parasitoids and/or Diaprepes larvae three weeks after parasitoid placement. Twelve of the 28 cages (42.9%) contained *A. vaquitarum* pupae, and a total of 167 *A. vaquitarum* pupae were recovered. These data demonstrate that *A. vaquitarum* attacked and developed to the adult stage on the weevil egg masses within the cages, and this suggests that the parasitoid may be able to survive climatic conditions found in southern California.

Host-specificity testing for another Diaprepes egg parasitoid, *Haeckliana sperata*, began in 2010 at the University of California-Riverside Quarantine Facility. In order to obtain permission for field release in California, we need to perform risk assessment of non-targets, especially those used for weed biological control. We are attempting to test eggs of 10 species of weevils that are weed biological control agents for oviposition by this parasitoid and/or subsequent parasitoid development. Three of proposed test species attack aquatic weeds, although the weevils themselves are not aquatic. All necessary permits for field collection and transport of these weevils and their associated plant species have been obtained. Techniques for obtaining the appropriate aged weevil egg and exposing it to the parasitoid have been developed. Initial trials with this parasitoid have found it to only attack Diaprepes eggs.

Other species of egg parasitoids belonging to the genus *Fidiobia* (Hymenoptera: Platygastridae) are also being investigated for possible use against Diaprepes eggs. With the assistance of USDA-APHIS, negotiations are underway with the country of Columbia to export *Fidiobia* parasitoids to a quarantine facility in Florida for further study. The export of these parasites may occur in 2011, and host specificity testing would begin once a colony is established in quarantine.

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Role of *Peristenus relictus* (Hymenoptera: Braconidae) in Mortality of *Lygus hesperus*

Charles H. Pickett, Marypat Stadtherr, and Daniel Wisheropp

Previous correlative data has shown that over time, recently colonized populations of *Peristenus relictus* are associated with decreases in Lygus populations. The actual impact of the parasitoid itself, apart from generalists predators found in the same environment, has yet to be documented. In an effort to measure this impact, a trial experiment incorporating the use of cages in an alfalfa field was tested. We report on the first summer's experience with using small field cages to partition the impact of parasitism from extant predators.

The study was conducted at our Program's Sacramento experimental farm, on a plot of alfalfa planted the previous fall. The entire plot of alfalfa was cut to 0.3 m on 22 July 2010 and then cages were set up the following day. Three Megaview® emergence traps (cages), spaced two to four meters apart (north to south; Figure 1) with a one meter square base and lips for burying into soil, were set up over alfalfa cut to 10 cm by hand with clippers (Figure 2). The same square meter was next vacuumed with a Stihl 55® hand-held vacuum (Figure 2) to remove all insects living in the duff. To further remove all insects from each Megaview® emergence trap, yellow sticky traps and collection bottles filled with 70% isopropal alcohol were placed at the top of each cage.

Figure 1. Treatment cages at North B St. September

Figure 2. Vacuum and cut alfalfa.

About two weeks later, on 18 August 2010, 207 adult *Lygus hesperus* were added to each cage, which was then closed. Sticky traps and collection bottles were removed prior to addition of *L. hesperus*. No insecticides were applied to the alfalfa before or during this study. On 3 September 2010, 50 female and 10 male *Peristenus relictus* were added to the 'North' cage, which remained closed. The middle cage was opened and the 'south' control cage remained closed. On 15 September 2010, cages were removed and the alfalfa within them examined for numbers of Lygus nymphs and parasitoids (*P. relictus*). This was accomplished by cutting the new growth of alfalfa to its base (about 5 to 10 cm), and placing on a sheet (Figure 3). The ground from which it was cut was then vacuumed to remove any *L. hesperus* or adult parasitoids that could be remaining in the duff. The cut alfalfa held by a white sheet was placed on a table for counting insects. This required sorting through the alfalfa and aspirating and counting all

moving *L. hesperus* nymphs. The vacuumed duff, held in a collection bag, was next counted on a white sheet and the number of Lygus nymphs aspirated and counted.

The same field was also monitored twice monthly for Lygus nymph densities and degree of parasitism by extant *P. relictus*. Four sets of 10 to 50 sweeps were taken, two along edges and the other two crossing the field at diagonals. Subsets of nymphs were returned to the Biological Control Laboratory and dissected with the aid of a microscope for the presence of egg and larval instars of *Peristenus*, as described in earlier reports. Identity to species was confirmed through rearing some of these to adulthood.

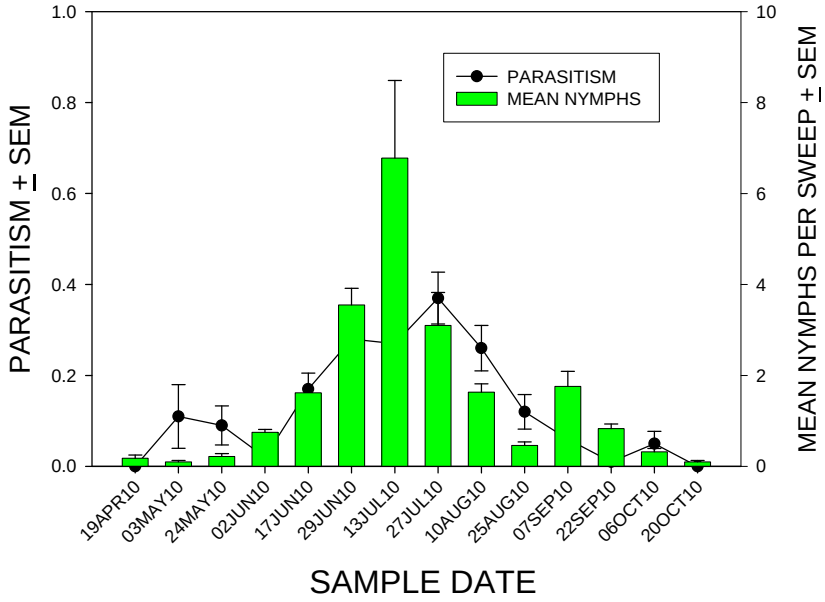
Figure 3. Caged vegetation being cut for sampling.

Although we did not replicate the treatments, resulting numbers of Lygus in each cage suggest that the released parasitoids had a greater impact on Lygus mortality than the generalist predators in the field. The closed, control cage, free of any parasitoids or predators, had the highest number of nymphs, almost three times as many as the closed cage containing *P. relictus* (Table 1). Numbers of Lygus nymphs in the open cage fell in between, and did not have any parasitism. Although we did not record numbers of predators in any of the cages, many spiders, syrphids, *Orius,* and *Geocoris* were present when collecting Lygus nymphs from the sampled vegetation and duff of the 'open cage.' Very few were present in the two closed cages.

Table 1. Results from cage study, summer 2010, North B St. study site.

Cage treatment	# Lygus			% Parasitism (n)	
	vegetation	ground	total	vegetation	ground
Closed	111	97	208	0 (30)	0 (30)
Open	24	112	136	0 (24)	0 (50)
Closed, plus *Peristenus*	18	60	78	16.6 (18)	44.4 (36)

Fig. 4. Lygus densities and parasitism, summer 2010, NB St.



Our expectation was that some parasitism would occur in the open cage, in addition to predation, from extant natural enemies. None occurred, however. Most likely by early September, when the middle cage was opened, there were very few adult parasitoids searching for host nymphs. Parasitism had dropped from a high of 36% to around 10% by that time of the summer, decreasing as the Lygus population plummeted (Figure 4). The high numbers of Lygus during midsummer probably occurred due to the replanting of the field creating a lush new crop, with very few parasitoids in the area, initially. Maximum numbers of Lygus nymphs have varied between one and five per sweep over the last few years, after reaching a high of nearly 16 in 2003. The cage representing only one square meter would rarely be visited by a searching parasitoid over a two week period (10 to 20% parasitism would result in about 100 to 200 parasitized nymphs in our 508 m^2 area of alfalfa); also the cage may have represented a deterrent to flying parasitoids. Although the 50 female *P. relictus* added to the cage is far higher than would occur naturally in that area of ground, it does show what kind of impact they could have when at a high ratio relative to its host. Our results also suggest that higher numbers of Lygus at the base of the plant were parasitized: 44% of the 60 counted. While a much smaller portion, 16.6%, of nymphs in the cut vegetation were parasitized. Next year, we will replicate the treatments, reduce the number of *P. relictus* added to cages, and record numbers of predators.

Acknowledgements

We thank Tom Dorsey for supplying *P. relictus* and Dale Spurgeon, USDA ARS, Shafter, CA for supplying adult *Lygus hesperus*.

Distribution of *Lygus hesperus* and the Parasitoid *Peristenus relictus* in Organic Strawberries with Alfalfa Trap Crops

Sean L. Swezey[1], Diego J. Nieto[1], Janet A. Bryer[1], and Charles H. Pickett[2]

Lygus hesperus (lygus bug) is a key economic pest in strawberries on the central coast of California. A novel approach to controlling these pests is to manipulate their spatial distribution in this crop through use of interplanted alfalfa trap crops. Here, alfalfa is used as to attract lygus bugs out of, or away from, strawberries, a high value crop. High spatial concentrations of lygus bugs in alfalfa would thereby be helpful in several ways. It can reduce the number of lygus bugs feeding on strawberries and make their removal (via vacuum or insecticide application) more efficient. Finally, high concentrations of lygus bugs may also be beneficial for the introduced lygus bug parasitoid *Peristenus relictus*. As with many specialized parasitoids, there seems to be a density-dependent response by *P. relictus* to lygus bug parasitism. Hence, a clustered distribution of lygus bug nymphs would provide pockets of high host densities that could elevate parasitism rates and subsequent numbers of *P. relictus* adults.

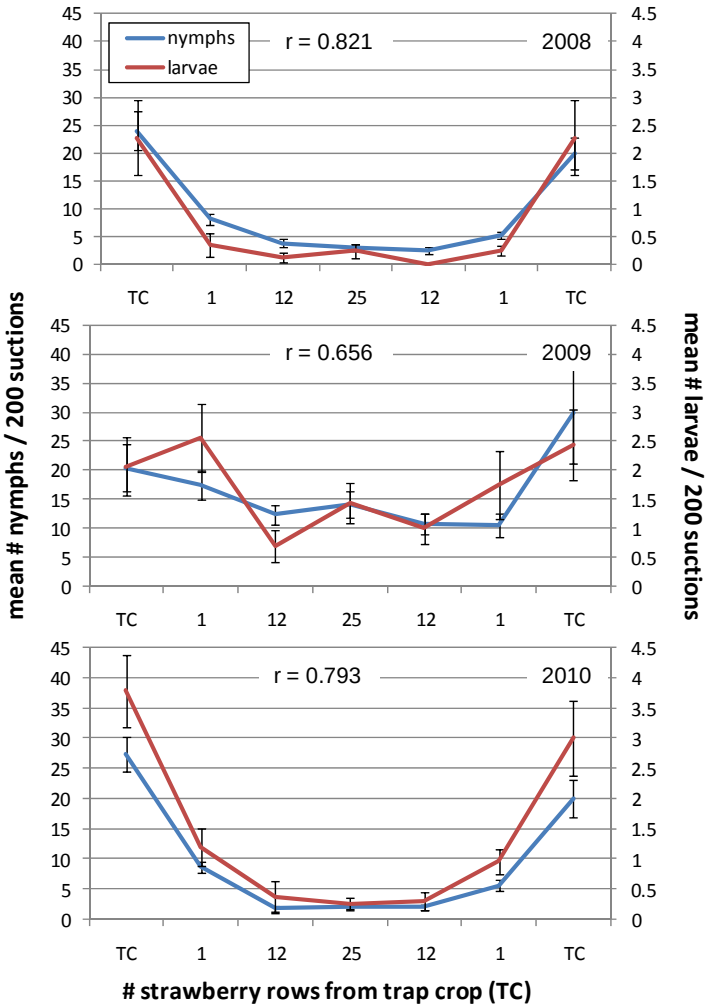


Figure 1. Mean lygus bug nymph and *Peristenus relictus* larval abundance in alfalfa trap crops (TC) and 50 adjacent strawberry rows. *P. relictus* larval counts are derived from dissected nymphs. Data collected from Aug-Oct. from Eagle Tree (2008, 2010) and Deadwood (2009) organic strawberry farms in Prunedale, CA.

To determine the distribution of lygus bug nymphs and *P. relictus* within rows of strawberries, samples were taken based on their proximity to one of two neighboring trap crops. Distribution data, which included nymphal abundance, *P. relictus* larval abundance, and percent parasitism, were collected from 2008 to 2010 in two organic trap-cropped strawberry farms in Prunedale, CA (Figure 1 and Table 1). A spatial transect was used that included two neighboring alfalfa trap crops and the 50 strawberry rows that separate them. Bi-weekly samples were taken with a hand-held vacuum (200 suctions/sample) from both alfalfa and strawberries to compare plant preferences and spatial trends. Collected lygus bug nymphs were placed in vials and shipped to CDFA for dissection.

Data indicate greater concentrations of lygus bugs and *P. relictus* centered around alfalfa trap crops in 2008 and 2010. These data generally demonstrate a "U-shape" of lygus and parasitoid distribution between trap crops: abundance is high in the trap crops and the adjacent row of strawberries and quite low when 12 and 25 rows away. Using a Pearson Coefficient Correlation, the abundance of host (nymphs) and larval parasitoids was strongly correlated during 2008 ($r = 0.821$; $p<0.001$) and 2010 ($r = 0.793$; $p<0.001$). In 2009, the distribution of lygus bugs and *P. relictus* were generally similar but not nearly as well delineated ($r = 0.656$; $p<0.001$). In 2009, data were collected from Deadwood Farm (rather than Eagle Tree Farm in 2008 and 2010), which experienced persistent lygus bug immigration from a neighboring field; consequently, this field was managed much more intensively (exposed to a tractor-mounted vacuum much more frequently) than was the case in either 2008 or 2010.

Table 1. Mean percent parasitism of lygus bug nymphs by *Peristenus relictus* in alfalfa trap crops and adjacent strawberry rows. Data collected from Aug-Oct. from Eagle Tree (2008, 2010) and Deadwood (2009) organic strawberry farms in Prunedale, California.

	2008	2009	2010
trap crop	7.8	12.2	20.4
row 1	2.4	18.8	12.0
row 12	2.1	6.5	12.1
row 25	5.0	12.5	16.4
row 12	0	12.1	9.7
row 1	7.3	15.0	18.4
trap crop	9.0	12.6	19.3

While lygus bug parasitism was typically greatest in alfalfa trap crops (where lygus bugs were most concentrated), *P. relictus* was recorded from almost every strawberry row in each sample year (all but row 12 in 2008), regardless of distance from a trap crop. In 2009, when densities of lygus bugs were elevated in the center-most strawberry rows, both larval abundance and percent parasitism responded accordingly (1.5 larvae/200 suctions and 12.5% parasitism in row 25). This seems to indicate that while *P. relictus* may be drawn to alfalfa and the high host densities found there, they will also seek out host populations in strawberry rows, particularly when concentrations are sufficiently high.

Regional Spread of the Colonized Lygus Parasitoid *Peristenus relictus* (Hymenoptera: Braconidae) in California

Charles H. Pickett, Diego Nieto[1], Janet A. Bryer[1], Sean Swezey[1], Daniel Wisheropp, Marypat Stadtherr, and Martin Erlandson[2]

The nymphal parasitoid *Peristenus relictus* in the last 10 years was successfully established for control of *Lygus hesperus* at two regions in California: the Sacramento Valley (since 2003), and Monterey Bay (since 2007). The establishment and spread of this parasitoid at our original release sites is associated with a decline in Lygus densities. To document the spread of this parasitoid and quantify how fast it is moving, a survey was initiated in 2009, using as starting points the two areas where this parasitoid has been permanently established. This information should help us prepare for additional releases.

Figure 1. *Peristenus* larva emerging from Lygus sp. nymph.

Collections were made in cardinal directions at each site; all four compass points at the Sacramento site, beginning spring 2010: but only north, east, and south at the coast site (Monterey Bay) beginning fall 2009. Collections were from intermediate (8 to 16 km), and far distances (32 to 60 km). Up to 200 sweeps or 400 vac's (from a hand-held vacuum) were used per replicate, with four replicates per site. Lygus nymphs were collected from wild flowering vegetation (mustards, wild radish, vetch typically near a water source) and from alfalfa, celery, and basil. Lygus were dissected for the presence of developing *Peristenus* (Figure 1). Because a native, though rare *Peristenus nr. pallipes* may also attack Lygus, all larvae were identified to species using a DNA marker developed by Gariepy et al. (2005).

Peristenus relictus was found approximately 55 km and 70 km from the original release sites in the Sacramento Valley and Monterey Bay, respectively (Figure 2). Assuming that parasitoids began dispersing when first released, *P. relictus* appears to have moved at least 4.6 km per year in the Sacramento Valley and 10.0 km per year in the Monterey Bay region. We hope to determine the limit of their spread next spring.

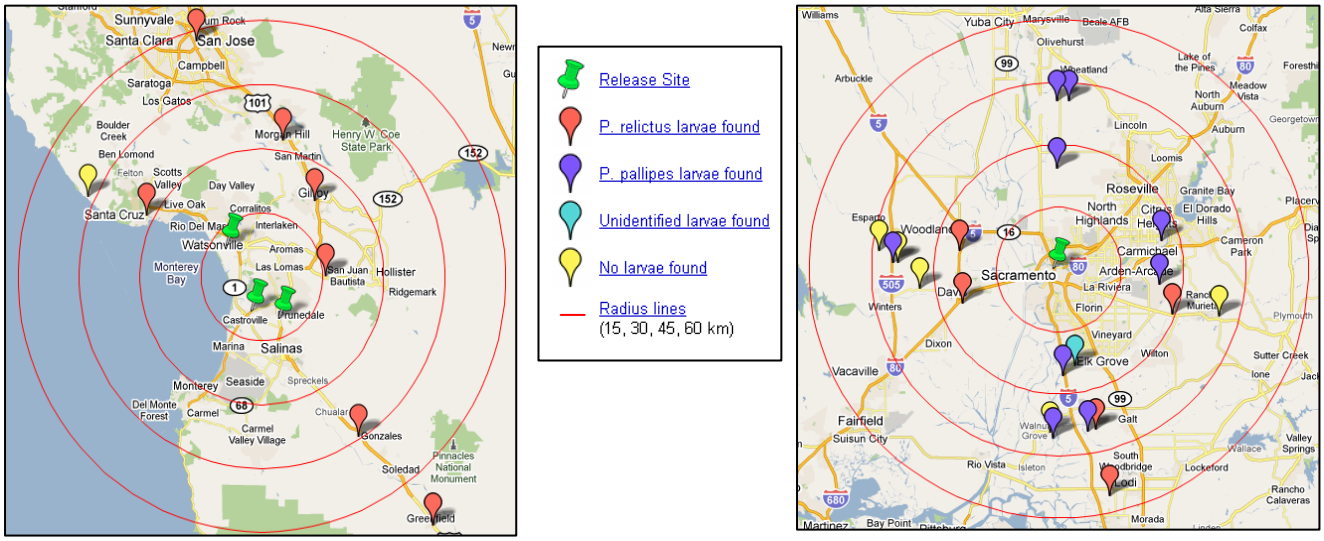


Figure 2. Spread of *Peristenus* from two original release areas in California. Samples collected in 2009 and 2010.

In Field Parasitism and Predation of Light Brown Apple Moth Eggs

William Roltsch, Nada Carruthers[1] and Richard Stouthammer[2]

Field studies were conducted for a second year on the population biology of several resident egg parasitoid species attacking the light brown apple moth, (LBAM), *Epiphyas postvittana* in California. Our intent is to develop augmentative biological control of LBAM, and possibly integrate augmentative biological control with other tactics such as pheromone-based mating disruption and sterile insect technique in suppressing LBAM populations.

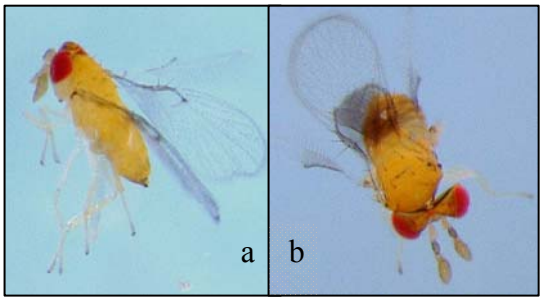


Figure. 1. a: *Trichogramma platneri* **b:** *T. fasciatum* collected from sentinel eggs.

Objectives for our field studies were: 1) identify *Trichogramma* species seasonal impact on LBAM eggs, 2) quantify the level of parasitism in relation to geographic variability and LBAM host plant species, and 3) quantify egg mortality levels caused by generalist predators.

Methods of study were the same as described in the 2009 report. Sentinel egg cards were placed approximately monthly from mid-spring to winter on Manzanita (*Arctostaphylos densiflora*) at Woodrow Av. in Santa Cruz and on several host plant species; Australian tea tree (*Leptospermum laevigatum*), *Choisya ternata*, *Myrtus communis* and *Acacia longifolia*) in San Francisco's Golden Gate Park. Additional sites received egg cards at less regular intervals. At locations in Santa Cruz (in addition to the Woodrow Av. site) and adjacent communities (i.e., Soquel and Aptos), sentinel egg cards were placed on manzanita and *Pitosporum tobira* at three or four locations each. This multi-site study was done three times in 2009 and twice in 2010. Monitoring also was conducted sporadically on *Leucodendron* sp. (also at the Woodrow Av. site) and *Myrtus communis* in downtown Santa Cruz.

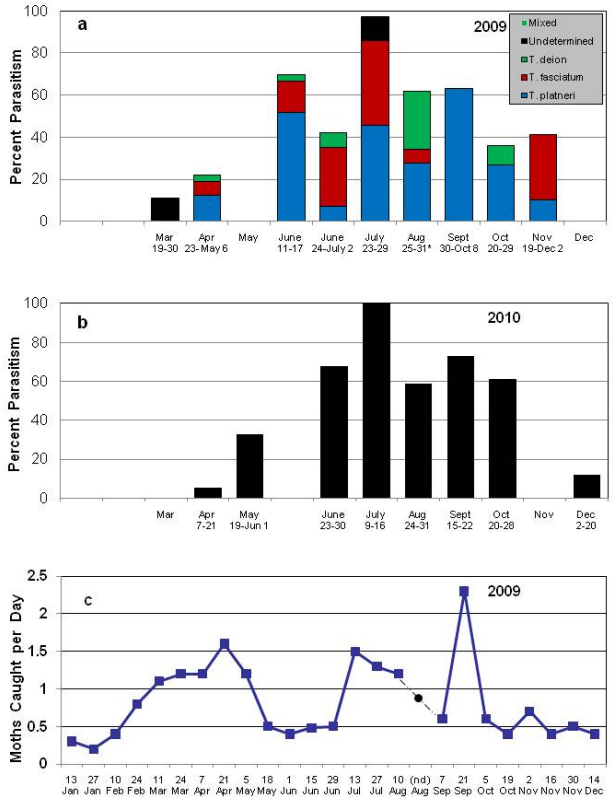


Figure 2. Parasitism of sentinel LBAM egg cards on manzanita at the high density LBAM site in Santa Cruz in 2009 and 2010 (**a** & **b**); accompanied by LBAM pheromone trap catch (**c**). [**nd** = no data]

The Woodrow Av. site in Santa Cruz continued to represent parasitism within a high density LBAM environment. Since 2007, LBAM densities at this site have been at sufficient levels to cause extensive defoliation of ornamental manzanita. Collection of parasitism data has been very revealing as to species composition, seasonal activity and impact. Periodic monitoring at other locations in Santa Cruz has provided a view of how *Trichogramma* spp. function under states of low LBAM density.

Frequent monitoring in Santa Cruz demonstrated that parasitism by wild *Trichogramma* is low during much of the spring period when LBAM moths are ovipositing (February to April), with an increase in late May and June subsequent to the late spring LBAM moth flight and egg lay (Figure 2). During summer periods of high LBAM densities, *Trichogramma* increase and cause very high levels of parasitism. However, our studies suggest that high egg densities are required for heavy levels of parasitism to occur by wild *Trichogramma* populations. *Trichogramma* population densities at the intensively monitored site declined to very low levels in the winter months (Figure 2 a-b). Not shown in Figure 2, 5% of the egg cards were parasitized (by *T. fasciatum*) in a sentinel egg study in January 14 to February. 4, 2010 at Woodrow Avenue. Therefore, it is apparent that *T. fasciatum* and perhaps other species are active at low levels (i.e., not in a state of diapause) during the winter months at central coastal locations. None of the egg cards placed on *Leucodendron* that same time were parasitized.

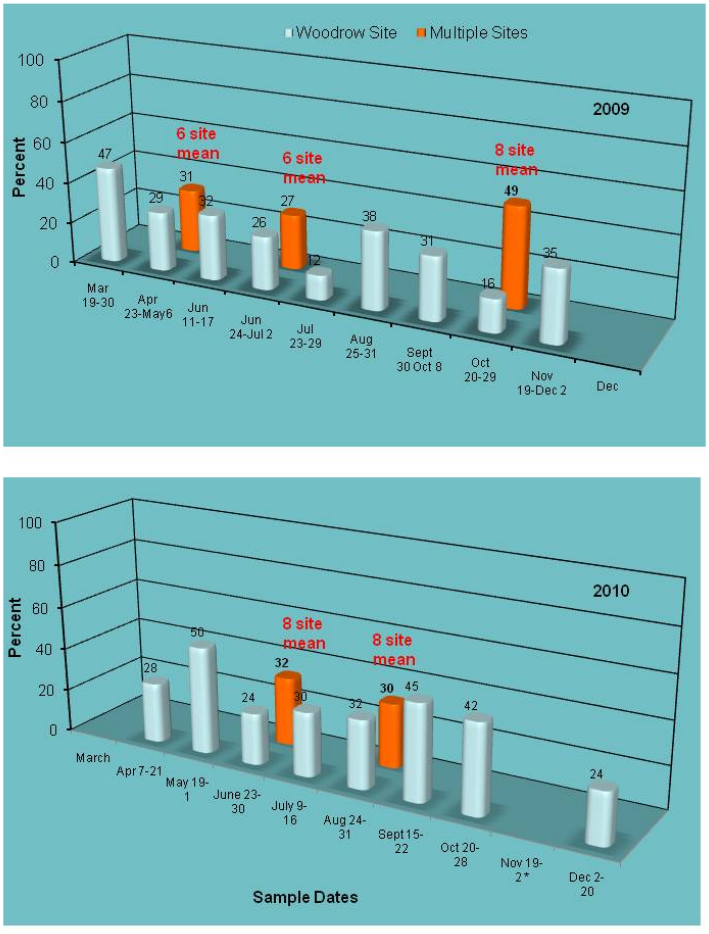


Figure 3. Percent of sentinel eggs with considerable predation (>50%) at primary research site (blue columns) and multiple locations (red columns) within 8 km.

Parasitism in San Francisco was seldom recorded until September. By early September of 2009 and 2010, egg parasitism increased. On the shrub *Choisya ternate* 54% and 17% repectively, of the egg cards were parasitized. On a tall *Myrtus communis* hedge, 29% and 0% of the eggs were parasitized respectively. Throughout the entire two years, parasitism was nearly undetectable on the young Australian tea tree, *Leptospermum laevigatum,* a favorable host of LBAM in the Golden Gate Park. During this time, only two parasitized egg masses were recorded from this plant species.

Predation of egg masses has been consistently detected throughout this study at all sites, most typically occurring at a level of 30-40% (Figure 3). Both parasitism and predation reported herein are conservative estimates of actually levels, since the egg cards are exposed in the field for less than the full developmental period (est. 50-75% of complete development) required by LBAM eggs. The causal agents of predation have not been determined. Likely candidates include earwings (Dermaptera) and ants (Formicidae).

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Seasonal Patterns of Activity and Larval Parasitism of Light Brown Apple Moth in Two Coastal Areas of California – 2010 Update

Nick Mills[1], Linda Buergi[1] and William Roltsch

LBAM populations have been sampled regularly at two sites in each of San Francisco and Santa Cruz from May 2008 through June 2010. Urban sites were selected for monitoring as LBAM continues to be largely an urban invader at the current time, with a small incursion into caneberries and strawberries along the central coast in 2009. In San Francisco, the most consistent host plant of LBAM has been the Australian tea tree (*Leptospermum laevigatum*) and in Santa Cruz a consistent host plant is an ornamental variety of the indigenous shrub manzanita (*Arctostaphylos densiflora*). LBAM populations have been sampled every two weeks at each site during the main season, and once a month in winter (November through February). Abundance is monitored by timed counts, the cumulative occupied leaf-rolls found within 5 min. of search on each of 22 plants at each site in San Francisco, and on 15 plants at each site in Santa Cruz. A sample of from 30-50 leaf-rolls are collected from each site on each sampling date to (1) determine occupancy, (2) determine stage structure, and (3) determine parasitism from parasitoid cocoons and live LBAM individuals present. The proportion of leaf-rolls occupied by 0, 1, 2 or 3 LBAM individuals are used to correct the leaf roll estimates for LBAM abundance. The stage structure provides a measure of the seasonality of LBAM development, although both eggs and adults are missing from these samples. Live larvae and pupae from the leaf-rolls are transferred to diet to rear through to adult for identification, and those that emerge from the rearing of field collected LBAM are identified where possible and used to estimate parasitism by indigenous parasitoids.

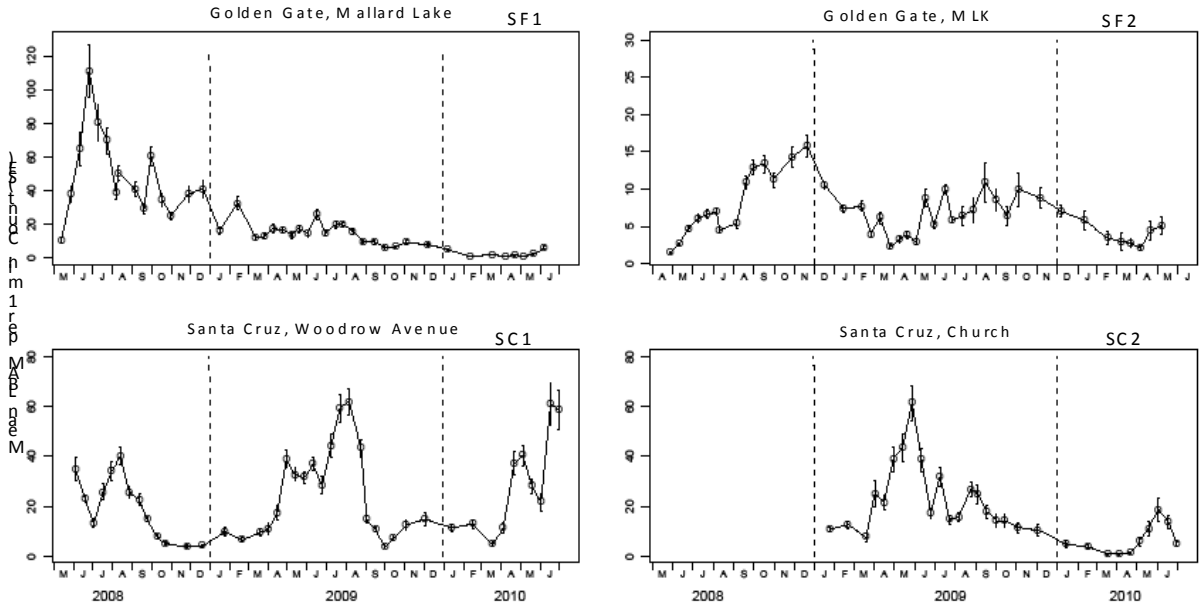

Figure 1. Abundance of occupied LBAM leafrolls in San Francisco (SF1 And SF2) and Santa Cruz (SC1 and SC2) from 2008 to 2010.

The abundance of occupied LBAM leaf-rolls on Australian tea tree (SF1 and SF2) peaked in 2008 at both sites in San Francisco (Figure 1), and has subsequently declined to levels that remain detectable but low. The highest densities of occupied LBAM leaf-rolls recorded from our field sites occurred in late June 2008 at SF1 and this was associated with young vigorously growing plants that have subsequently grown much larger and less vigorous in their growth. The abundance of LBAM on manzanita in Santa Cruz has remained relatively high, building to distinct peaks of abundance in June each year, and declining to much lower densities in winter (Figure 1).

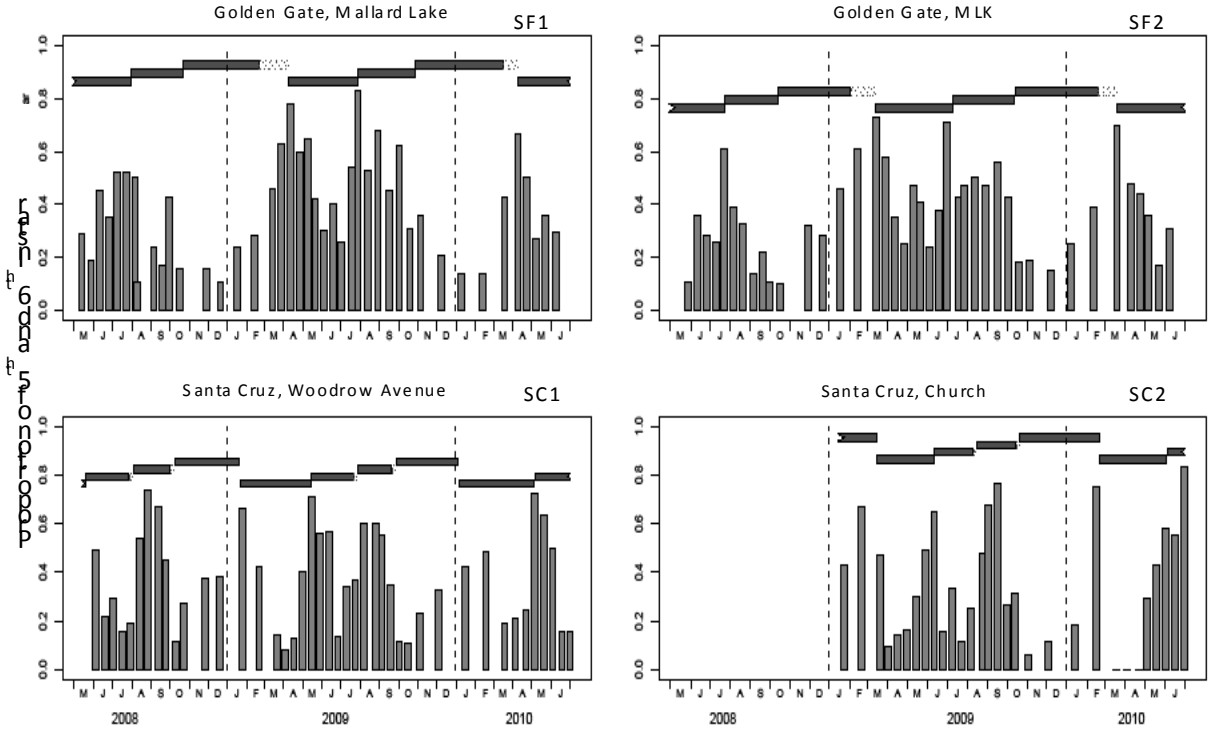

Figure 2. The phenology and voltinism of LBAM in San Francisco (SF1 and SF2) and Santa Cruz (SC1 and SC2) as shown by the relative frequency of late (5th and 6th) instar larvae (vertical bars) and the 646 degree day intervals required for LBAM to complete a generation (horizontal bars).

The pattern of seasonal phenology and voltinism of LBAM differs between San Francisco and Santa Cruz, as indicated by the stage structure of the populations. This is best illustrated by the relative abundance of late instar larvae ($5^{th}/6^{th}$) in relation to the thermal requirement for the completion of a generation by LBAM (Figure 2).

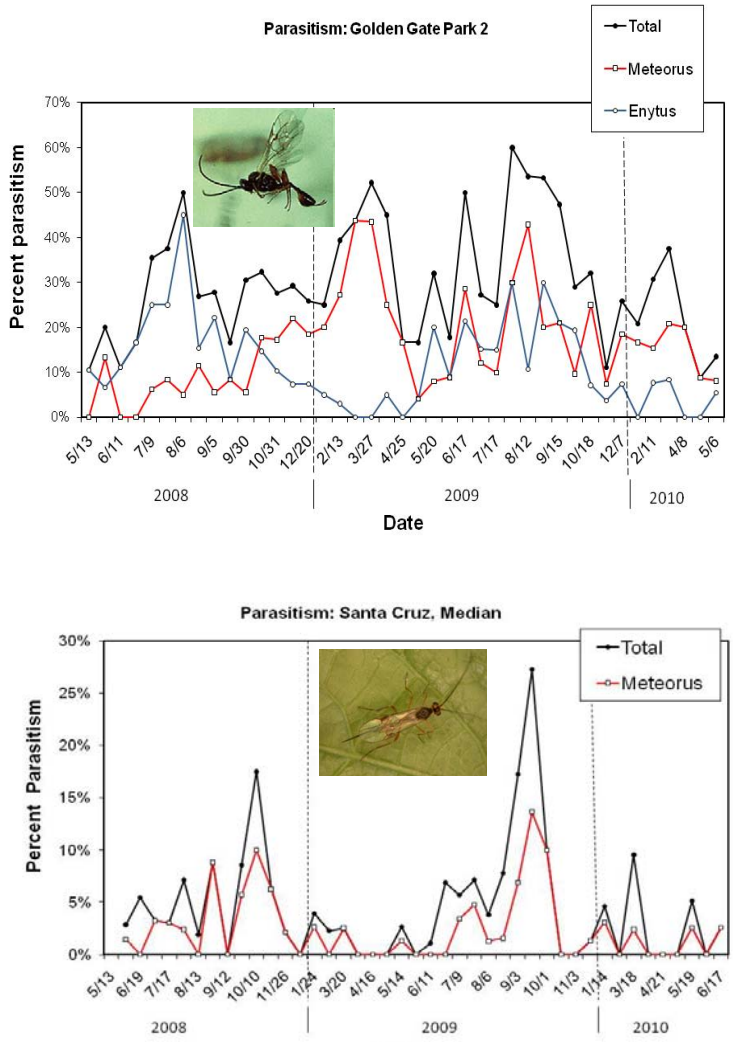

Figure 3. Parasitism of LBAM larvae and pupae from 2008 to 2010 in San Francisco and Santa Cruz.

From these two measures, it appears that there are three generations of LBAM in San Francisco and four generations in Santa Cruz, one more generation in each location than we had previously thought. The generations greatly overlap with all larval stages present throughout the main season from April to October, and thus the patterns for any one life stage are not always distinct. However, by combining stage structure with temperature driven voltinism, we can see peaks of late instar larvae in April/May, July, and October/November in San Francisco, and in January/February, May/June, July/August and September/October in Santa Cruz (Figure 2).

Larval and pupal parasitism at the four sites monitored has been dominated by two parasitoids *M. ictericus* and *E. eureka*, although the latter species continues to contribute little to parasitism in Santa Cruz (Figure 3). We had previously identified the *Meteorus* as *M. trachynotus*, a Nearctic species known as a parasitoid of *Choristoneura* budworms. However, use of molecular markers (based on CO1 and 28S) has recently confirmed that the California parasitoid is *M. ictericus* a Palearctic species know from a variety of larger tortricid leafrollers. In San Francisco, apparent parasitism has been as high as 60%, with *M. ictericus* particularly active in spring, while *E. eureka* has dominated the parasitism from mid-summer (Figure 3). In contrast, in Santa Cruz, parasitism has peaked at 15%, with *M. ictericus* activity low in spring and greater at the end of summer. The greater rates of parasitism in San Francisco are likely to result from the greater activity of *E. eureka*, and the longer period of larval development (with only three generations per year) in this area.

In addition to the parasitism recorded from these sample locations, two parasitoid species have been consistently recovered from other locations since late summer 2009, an egg parasitoid *Trichogramma fasciatum* , and a gregarious pupal parasitoid, *Pediobius* sp., both in Santa Cruz and San Francisco. Also, the native egg parasitoid, *T. platneri,* is common in the Santa Cruz area.

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Olive Psylla: Foreign Exploration 2010

Charles H. Pickett, Javid Kashefi[1], Kent M. Daane[2], and John Hutchins[2]

The olive psylla, *Euphyllura olivine*, first reported in California in 2007 is currently confined to southern California but can potentially spread north into the olive production areas of California. When first surveyed, infestations were found within 20 km of coastal communities in San Diego and Orange counties. Surveys conducted by M. Johnson (unpubl. data) in 2009 and 2010 found that the psyllid has expanded up to 30 miles inland: Fallbrook and Temecula, adding Riverside County to its range. In 2010, the psyllid was also found for the first time in Monterey County at a private residence. In Europe and the Mediterranean Basin, the olive psylla pest problem is composed of three closely related species, *Euphyllura olivina*, *E. phillyreae*, and *E. straminea,* with the former found mainly in the western half of the Mediterranean Basin. Because the olive pyslla has the potential for damaging high numbers of olive flowers during spring months, we decided to investigate the potential for importing parasitoids of the pest. In 2009, a survey conducted in northeastern Spain, southern France and Greece found one species of encyrtid attacking olive psylla, *Psyllaephagus euphyllurae*. In 2010, another trip was made to northeastern Spain and southern France in order to bring live *P. euphyllurae* back to California.

Figure 1. Olive psylla infesting infloresence of olive, southern Spain.

There is a narrow window of opportunity for finding high densities of mummies (without exit holes), and it is highly variable throughout the region. Last year (2009), collecting in late April, we were probably at the best time for the psyllid, but not for the parasitoids. The timing of the 2010 mid-June trip was perhaps a week late for coinciding with the best collecting of olive psylla mummies. In 2010 we found one of 10 locations with high densities of mummies, but these were heavily attacked themselves by a hyperparasitoid. Southern Europe had an unusually cool spring so we had delayed this trip by three to four weeks; one week earlier might have been better. By the time that I (CHP) arrived in Europe, my contact in Spain, Dr. Juan A. Sanchez informed me that populations in Murcia (where we found the highest densities spring 2009) were already scarce.

The first day of collecting was near the European Biological Control Laboratory (EBCL), Montferrier-sur-lez in Southern France, with help from Alan Kirk and Dan Strickman. We spent about five hours collecting along the forest path near the lab, at the base of Pic St. Loup, and just outside the village of Puechabon (Table 1). Psylla populations were light everywhere, but we did see some mummies at the Puechabon site. On the drive down to Spain the following day, Javid Kashefi and I (CHP) sampled from a young olive orchard west of Peripignan (Millas). We saw just a few psylla. We then went on to the Delta region south of Barcelona where we spent two days just outside of Ulldecona. There were scattered olive trees throughout the area. Light

populations were found on one of 20 trees within walking distance (south) from the hotel. We spent much of the day at the Delta site (Table 1), our best location for collecting in 2009, about 50 km from our hotel and we collected about 200 mummies in five hours. We collected from our previous site (2009) of scattered commercial trees near wild ones, and from a new location of commercial olives down the road. About 30% of mummies had exit holes, suggesting the current parasitoid generation was nearing completion. Most of the psylla were late instar and it was easy to find adults. One adult encrytid was seen resting on an olive stem, looking very much like our target.

We were able to process samples in the hotel using a shared room on the second floor. Although the hotel lacked WIFI, they offered use of their internet service and laptop. On our return trip north back to France, we stopped again near Peripignan, going NW on D12, suggested by Alan Kirk. Stray olive trees were common along this road but no mummies or psylla were found and it was very windy.

Table 1. Collection data, June 2010. Spain and France. Map datum = WGS84, hddd.dddd°.

Date of Collection	Waypoint #	Site Name	Latitude	Longitude	Psylla** pop. Level	Mummy pop. Level
17 June	94	EBCL, forest	N43.68552	E003.88271	++	
17 June	99	Pic St. Loup	N43.78896	E003.83520	++	
17 June	120	Puechabon	N43.71138	E003.62335	++	+
18 June	121	Millas	N42.69284	E002.68113	+	
18 June	122	Rest Stop* nr. Delta	N40.98639	E000.89536	++	+
19 June	123	El Rajolar Hotel	N40.59845	E000.39719	++	+
19 June	125	Nr. El Rajolar Hotel	N40.59657	E000.40159	++	
19 June	45	Delta, wild	N40.65953	E000.58606	+++	+++++
19 June	126	Delta, commercial	N40.63626	E000.59724	+++	+++++
20 June	126	Delta, commercial	N40.63626	E000.59724	+++	+++++
20 June	127	Peripignan	N42.79121	E002.85767	+	

*single tree
** scale of 1 -5, one ‘plus’ being lowest.

We spent the last day at EBCL processing samples for the Spanish collections, and for the French collection. We did not finish and Arnaud Blanchet made a shipment for us sending whatever else emerged from cuttings over the following week using the courier SDV. Arnaud prepared a notice of declaration for my hand carrying sample, and suggested contacting USDA APHIS about adding more detail to the permit including ‘plant parts’ and ‘dead and dying’ hosts to the contents of my hand carrying permit.

Out of 224 mummies returned to the UC Berkeley Quarantine, only 12 adult *Psyllaephagus* emerged (Table 2). The remainder were hyperparasitoids, a species of *Alloxysta* sp. (Cynipoidea: Figitidae). A new generation of 10 *Psyllaephagus* emerged from original material in late December, despite a pause in reproduction by both host psylla and parasitoids since June.

Table 2. Emerged insects from collections shown in Table 1.

Site (see above)	# mummies	# hyperparasitoids	# *Psyllaephagus*
Delta (Spain), wild olives, #46	108	61	6
Delta (Spain), commercial olives, #126	95	55	5
Puechabon (France), commercial, #100	21	8	1
Total	224	124	12

We kindly acknowledge the help of Alessandra Rung, Plant Pest Diagnostics Laboratory, CDFA for identification of the psyllids, and acting Director of the European Biological Control Laboratory, Dan Strickman, for use of laboratory space and help. We also thank John Noyse and Andy Polaszek of the British National Museum, for identifications and Dr. Juan Antonio Sanchez (IMIDA, Spain) for help with collecting.

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Foreign Exploration for Parasitoids of the Lettuce Aphid, *Nasonovia ribisnigra:* Spring 2009 and 2010

Charles H. Pickett, Kent M. Daane[1], and Oscar Alomar[2]

The European lettuce aphid, *Nasonovia ribisnigra*, (native to Europe), invaded California about 12 years ago. It has become one of the most serious pests of lettuce throughout the state, especially on romaine varieties. The European lettuce aphid infests the innermost leaves of lettuce, which protect aphid colonies from pesticide applications and also, natural enemies. Although a number of generalist predators are known to attack this aphid in California, the tightly packed leaves limit access by natural enemies. There may be as many as three parasitoids specialized in attacking this aphid in southern Europe. The most commonly found wasp attacking the European lettuce aphid on lettuce grown in northeastern Spain is *Aphidius hieraciorum*. It is considered indigenous to this part of the world and is absent from California. Our goal is to import and release into California *Aphidius hieraciorum* and other wasps demonstrating specificity for this pest.

Figure 1. European lettuce aphid mummy on lettuce, Catalunya, Spain April 2010.

During a foreign exploration trip in April 2009, lettuce was sampled just outside of Barcelona, Spain with the help of a local entomologist, Dr. Oscar Alomar. Dr Alomar is a research scientist with Cataluyna, Spain's Institute of Technology and Agricultural Research, located in the city of Cabrils, north of Barcelona. We took trips to three small farms of organically-produced lettuce, one of which had the European lettuce aphid (site #65, near the town of Castellbisbal, Table 1). From 30 mummies of European lettuce aphid (Figure 1, note the strips on the dorsum), 13 female and seven male *Aphidius* emerged. In April 2010, another trip was made to the same region. Six, small organic lettuce farms known to have aphid problems were located and sampled, including again site #65 from 2009. From these six locations, only sites #65 and #103 near the town of Palafolls had mummies of the European lettuce aphid. Site #103 was another small organic family farm where lettuce production is under plastic. Sampling continued at these sites for two more days.

Figure 2. *Aphidius hieraciorum* mummy

I (CHP) had planned on going south to the Murcia area, but was discouraged by my contact there, Dr. Juan Sanchez, because the aphid populations were very low. Instead, I drove to Madrid where I met with Dr. Alberto Fereres, director of the Center for Agricultural Sciences, and author of a paper on the importance of *Aphidius hieraciorum* in controlling the European lettuce aphid, and its specificity for this pest. With the help of his staff, Dr. David Calvo, and Saioa Legarrea, we visited one lettuce farm outside Madrid. We found at least two species of aphids, *Macrosiphum* sp. and *Acyrthosiphon lactucae*, on romaine lettuces but not the European lettuce aphid. The weather had been unusually cool and wet that spring and lettuce production in that

region was delayed. However, with Dr. Fereres' help, I got descriptions and photos of *Aphidius hieraciorum* (Figure 2) as well as a referral to a braconid specialist at the University of Valencia, Dr. Jose Manual Michelena, a specialist of *Aphidius*.

I next sampled from an organic lettuce farm in the Montpellier, France region. Patrick Marcotte who works for a growers' association, set me up with a lettuce grower who farms just south of Nimes. With Alan Kirk's help (USDA ARS European Biological Control Laboratory), we spent one afternoon sampling from red bib lettuce and found a few *Nasonovia* mummies.

In all, I collected 89 mummies from mainly romaine lettuce. Some of these mummies developed from nymphs during this trip. I kept all mummies in small glass vials, streaked with honey, plugged with cotton and placed into small plastic baggies. These were placed on blue-ice in a cooler. I maintained a 'Watch Dog' (SpecWare®) with samples to record temperature of exposure which did not go over 15°C or below 5°C. The samples came off of blue ice when I left Montpellier. The following day at the Charles De Gaulle Airport outside Paris, I was questioned by airport officials just before boarding the plane, about the contents of my box. I successfully hand carried samples, using a permit plus red and white labels to pass through HomeLand Security in San Francisco. From the 89 mummies collected in 2010, only seven successfully emerged and we were unable to initiate a culture of *Aphidius*. Two specimens from this collection were positively identified by Dr. J. Michelena as *Aphius hieraciorum*.

Table 1. Site information for organic samples sampled for lettuce aphid. Map datum= WGS84

Site number	Date	Location	GPS units	Elevation (m)	# mummies	# emerging
63	29 April 2009	Barcelona, Spain	N41.40478 E002.01008	20	0	---
64	29 April 2009	Barcelona, Spain	N41.39570 E002.02493	16	0	---
65	29 April 2009	Spain: Southwest of Barcelona, Jaume Magrans	N41.47287 E001.95980	39	30	20
65	14,17 April 2010	Spain: Southwest of Barcelona, Jaume Magrans	N41.47287° E001.95980°	39	52	2
101	13 April 2010	Spain: Palafolls, organic farm, outside	N41.68309° E002.75312°	1	0	0
101	13 April 2010	Spain: Palafolls, organic farm, outside	N41.68200° E002.75292°	1	0	0
103	16 April 2010	Spain: Palafolls, organic farm, inside hot house	N41.68242° E002.75285°	1	32	3
104	13 April 2010	Spain: Matador, north of Barcelona, organic farm on coast	N41.55367° E002.48316°	15	0	---
105	13 April 2010	Spain: Vilassar del Mar, north of Barcelona	N41.50264° E002.37649°	27	0	---
107	14 April 2010	Spain: Owner, Pascuel, south of Barcelona	N41.35741° E002.05582°	11	0	---
112	19 April 2010	Spain: Madrid, Gneis Farm, near Velilla de San Antonio	N40.37825° E003.50487°	498	1	0
113	21 April 2010	France: Balandran Place, near village of Bellegarde	N43.75669° E004.46360°	43	3	2

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Parasitoid Releases for Vine Mealybug in Grapes

Kris Godfrey, Kathleen Casanave, and Iryna Golub

The vine mealybug, *Planococcus ficus*, is a serious pest of vineyards throughout much of the grape-growing regions of California. This insect causes direct damage to the berries, decline in the vines and may vector some leafroll viruses. Management programs have relied heavily on insecticides in the past, but more sustainable management programs are being developed. Biological control is one component of the sustainable management program for vine mealybug (VMB). A cooperative project with the University of California-Berkeley was established in 2005 in an attempt to increase the contribution of biological control to the management of VMB populations. Over the past four years, foreign exploration has been conducted in an attempt to find VMB parasitoids for California. Several strains of *Anagyrus pseudococci* from various parts of Europe and the Middle East have been researched. The strain from Spain (known as the Spanish strain) appears to be the best suited for release in coastal and central California vineyards that are infested with VMB. In 2010, we made releases of the Spanish strain of *Anagyrus pseudococci* at six sites in San Joaquin County. Each site received 3,675 females and 1,835 males between June 15 and October 1. A total of 22,050 females and 11,010 males were released. To determine the strain of *Anagyrus pseudococci* recovered required examination of the DNA of each parasitoid. The results of the monitoring of these releases are pending.

Figure 1. Monitoring the vine mealybug populations on vines after releasing parasitoids at a vineyard in the San Joaquin Valley.

Use of Mating Disruption to Reduce Damage by Citrus Leafminer in Nurseries

Kris Godfrey

The citrus leafminer has been steadily moving northward in California and can now be found as far north as Solano, Sacramento, and Placer Counties. This insect is a serious pest of young (less than four years of age) citrus trees. The mining activity of the citrus leafminer can cause young trees to be completely defoliated. Repeated defoliation episodes can kill young trees, and as such, this insect causes great concern in citrus nursery production. Insecticides can be used to limit the defoliation in conventional production, but there are few options for managing this insect in certified organic nursery production. One possible tactic for use in certified organic production is mating disruption using the citrus leafminer pheromone without carriers or additional formulation ingredients that may not be compliant with the National Organic Program.

To determine if mating disruption could be used to minimize damage in a certified organic block of citrus nursery stock, a study was initiated at a nursery in Solano County. This nursery has a small certified organic production block (Figure 1) located near conventional citrus nursery production and a conventionally-managed demonstration citrus orchard (Figure 2). The certified organic production block is approximately 25 meters from a loosely-screened enclosure with citrus mother plants (conventionally managed) and about 50 meters from the demonstration orchard. The demonstration orchard contains examples of all the varieties of citrus that this nursery produces, and there are approximately 40 – 50 trees within the orchard.

Figure 1. The certified organic citrus block with citrus leafminer pheromone traps at nursery in Solano County in 2010.

Figure 2. The demonstration citrus orchard at a nursery in Solano County in 2010.

Saturation of the area with citrus leafminer pheromone was achieved using various trap and lure densities through time. Trapping around the certified organic block consisted of placing 10 traps (5 traps placed on the north edge and 5 traps on the south edge) spaced approximately five meters apart. The demonstration citrus orchard was trapped with two citrus leafminer pheromone traps, one at the south end (farthest from the certified organic block) and one at the north end (farthest from the certified organic block), and served as a "treated control" (i.e., populations of citrus leafminer would increase in this orchard and then would be treated with an

insecticide). Trapping began on February 23, 2010, with the placement of traps each containing one citrus leafminer pheromone lure (1.33 mg of pheromone per lure, commercial preparation compliant with the National Organic Program). The traps were replaced at approximately monthly intervals. From May 18 through October 28, 2010, two lures were placed in each trap on each sampling date. To manage citrus leafminer in the demonstration orchard and in the rest of the conventionally managed nursery, the citrus was treated with spirotetramat (Movento) on May 15 and July 6, and with acetamiprid (Assail) on August 14, 2010. Each time the traps were serviced, an estimate was made of the percentage of new foliage that contained citrus leafminer in both the demonstration orchard and the certified organic block.

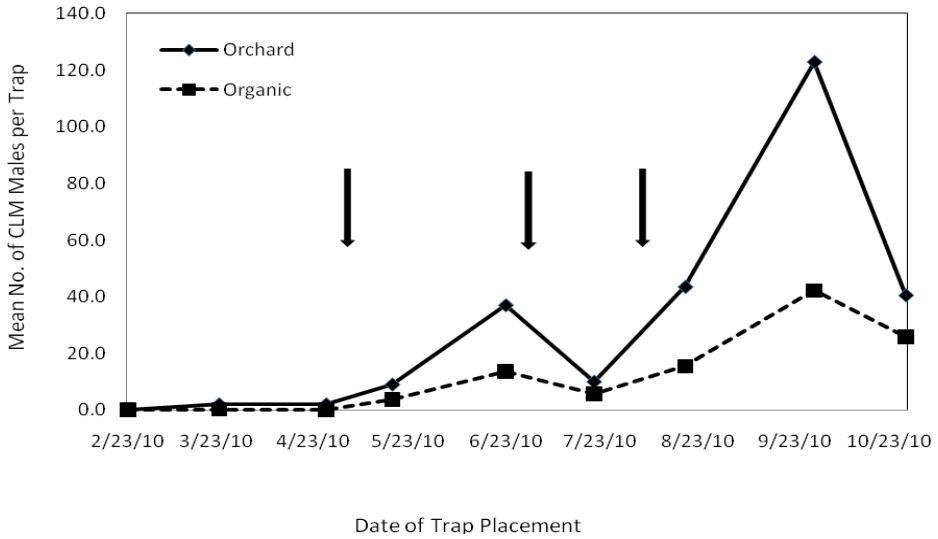

Figure 3. The mean number of male citrus leafminer moths in pheromone traps placed in the demonstration orchard and around the certified organic block at a nursery in Solano County in 2010. Arrows indicate timing of an insecticide application in the demonstration orchard.

The density of citrus leafminer males in pheromones traps was lower in traps placed in the certified organic block than traps placed in the demonstration orchard throughout most of the trapping season (Figure 3). Declines in the density of citrus leafminer in the demonstration orchard occurred after application of insecticides. Damage to new foliage within both the demonstration orchard and the certified organic block was extremely low. In late April and early May, and again in late October, approximately 5% of the leaves examined in the demonstration orchard showed mining from citrus leafminer. In the organic block, new leaves were present on each sampling date. However, mines were found only in late October and only about 2% of the plants examined had mines. The young nursery trees in the organic block produced more flush than the mature trees in the demonstration block and should have been more attractive to citrus leafminer moths for oviposition. This increased attractiveness of the young plants should have resulted in higher trap catches in the organic block than in the demonstration block because more female moths should have been present in the organic block seeking oviposition sites. Saturation of the certified organic block with pheromone appeared to confuse the citrus leafminer males and reduce the density of leafminer within the block compared to the conventionally managed block.

Exotic Wood Borer and Redbay Ambrosia Beetle Surveys 2009-2010

Curtis Takahashi and Richard Penrose

Exotic wood borers and other exotic tree attacking arthropods present a substantial risk to North American forestry, agriculture and urban landscapes. General and directed surveys provide early detection results to provide control and management options. Two large-scale surveys, The Exotic Wood Borer Survey and The Redbay Ambrosia Beetle Survey, are reported here describing results from both 2009 and 2010.

Exotic Wood Borer Survey

The primary objective of this year's Exotic Wood Borer Survey was to detect exotic insect pests while continuing to inventory California's woodborer fauna. Targeted insects included those in the following families: Bostrichidae (bostrichid beetles), Buprestidae (metallic wood boring beetles), Cerambycidae (longhorn beetles), the subfamilies Platypodinae and Scolytinae (bark and ambrosia beetles) of the Curculionidae, and the Siricidae (horntails, wood wasps). Woodborers of particular interest included species in the following genera: *Anoplophora*, *Callidiellum*, *Hesperophanes*, *Monochamus*, *Tetropium*, *Xylotrechus*, *Arhopalus*, *Chlorophorus*, *Purpuricenus* (*Stenoplistes*), *Agrilus*, *Pityogenes*, *Tomicus*, *Trypodendron*, *Xyleborus*, *Scolytus*, *Ips*, and *Sirex*. Species targeted for detection: *Anoplophora glabripennis, A. malasiaca*, *Callidiellum rufipenne, Hesperophanes campestris, Monochamus alternatus, Tetropium fuscum, T. castaneum*, *Xylotrechus* (exotic species), *Arhopalus syriacus*.; *Chlorophorus annularis, Purpuricenus* spp., *Agrilus anxius*, *A. planipennis*, *A. coxalis*, *Pityogenes chalcographus*, *Tomicus piniperda*, *Trypodendron domesticum*, *Xyleborus pfieli*, *Ips typographus*, *Scolytus schevyrewi*, *Orthotomicus erosus, Xylosandrus germanus, Euwallacea fornicatus. Hylurgus ligniperda, H. palliatus, Neoclytus acuminatus, Icosium tomentosum*, and *Sirex noctilio*.

The 2009 and 2010 surveys included traditional routes of pest entry, (airports etc.), artificial movement of woodborers across borders with adjacent states as well as extant pest reservoirs. The best reservoir habitats were determined to be large regional parks and arboretums located within or near large urban populations. These parks often represent ideal habitats where invading species can establish and continuously breed. Favorable attributes of these habitats include plant communities that are a mixture of native and introduced plant species of various age classes, and large areas that are undisturbed (i.e., no active removal of dead plant material). Also, because these more "natural areas" are frequently only accessible by trail, the potential for trap loss/damage was reduced. Green waste landfill and composting operations were also given priority based on historical detection data and because potentially infested wood from a number of local sources are accumulated at these sites.

Redbay Ambrosia Beetle Survey

The Redbay ambrosia beetle (*Xyleborus glabratus*) is a new insect pest from Asia. Internal feeding by adults and larvae cause direct damage to attacked trees, but, more seriously, this beetle has been shown to vector the pathogen laurel wilt fungus (*Raffaelea lauricola*). The beetle and the fungus were recently found in Georgia, South Carolina, and Florida. The fungus is especially virulent against native trees such as redbay laurel and sassafras, and can kill a mature redbay laurel tree in as little as six weeks. The California Department of Food and

Agriculture has performed a survey of several coastal counties where avocado production and stands of the California bay laurel tree occur. Areas surveyed include dooryard host plants in residential areas, host plants near commercial avocado production areas, and native stands of California bay laurel in coastal areas from San Diego County to the San Francisco Bay area.

SURVEY PROTOCOLS

Lindgren Funnel Traps - Lindgren Funnels were placed at a variety of locations. The highest numbers were deployed at recreational areas, including county and regional parks, campgrounds, USFS and State forest lands and refuges. Other monitoring locations included landfills, golf courses, ports, nurseries, log decks, tile and rock dealers, arboretums and botanical gardens, military housing, airports, universities, state forests, USFS fire stations, and private residences.

Twelve unit funnels (wet option) baited with UHR Ethanol (ETOH), UHR Ethanol + alpha pinene (ETOH + AP), Exotic Ips lure (IPS), or Sirex lure (SIREX) were deployed and serviced on a two-week schedule. All four traps at each site were serviced biweekly.

Exotic Woodborer Lindgren Funnel Traps were placed and serviced at 71 locations in the following 26 counties: Alameda, Butte, Contra Costa, Del Norte, El Dorado, Fresno, Kern, Los Angeles, Madera, Marin, Mendocino, Monterey, Orange, Placer, Sacramento, San Bernardino, San Francisco San Luis Obispo, Santa Clara, Santa Cruz, San Joaquin, San Mateo, Shasta, Tulare, Ventura and Yolo.

Samples were individually placed in paint filters, labeled, and sent to the laboratory for processing. After samples were cleaned of sticks, leaves, mud and other debris, wood borer samples were separated, mounted, and screened for the presence of wood boring beetles. According to survey protocols, all woodborers were to be identified in order to detect other exotic species that are not specifically targeted.

For the Redbay Ambrosia Beetle Survey, avocado growing areas and native range of Bay laurel trees were emphasized, traps being placed in both commercial and residential properties with avocado trees present. The traps were baited with manuka oil and serviced every two weeks.

A total of 201 Redbay Ambrosia Beetle traps were placed and serviced in the following counties: Los Angeles, Marin, Orange, San Diego, San Francisco, Santa Barbara, Santa Clara, and Ventura.

Samples were individually placed in paint filters, labeled, and sent to survey laboratory located in San Jose for processing. After samples were cleaned of sticks, leaves, mud and other debris, wood borer samples were separated, mounted, and screened for the presence of Redbay Ambrosia Beetles. In addition to survey protocols, all woodborers were identified in order to detect other exotic species that were not specifically targeted.

Sorted beetles awaiting mounting.

Mounting insect specimens prior to final screening.

Mounted specimens awaiting identification.

Pinned specimens awaiting determination.

Xyleborinus saxesenii (Ratzeburg), a common introduced scolytid beetle.

SPECIMEN COLLECTION/IDENTIFICATIONS

All Lindgren Funnel samples were processed at the Exotic Woodborer Laboratory in San Jose, California. Initial species determinations/screenings for the longhorn beetles, siricid wasps and the common and more easily recognized species of buprestids, scolytids, and bostrichids were performed by woodborer survey personnel. Determination and confirmation of unknown bark beetles was provided by scolytid specialist James R. LaBonte, Insect Specialist, Oregon Department of Agriculture. Andrew Cline, CDFA Insect Biosystematist, identified unusual and rarely-collected species of scolytids and bostrichids. Charles Bellamy, CDFA Insect Biosystematist, identified the buprestid beetles.

As of the date of this report,

-one new species of scolytid beetle, *Dactylotrypes longicollis,* was intercepted. This is a new record to the United States.

-no Redbay Ambrosia Beetles were intercepted although one new species of scolytid beetle, *Araptus schwarzi,* was detected. This also is a new species record for the United States.

Dactylotrypes longicollis (Wollaston)

James LaBonte, Insect Taxonomist, Oregon Department of Agriculture, Salem, provided the initial identification. Final confirmation was provided by Rob Rabaglia, US Forest Service, Arlington, VA.

This species is endemic to the Canary Islands. Known hosts include; *Butia eriospatha, Chamaerops humilis, Phoenix canariensis, P. pumila,* and *Trachycarpus excelsus.*

Records – **Orange Co.,** California State Arboretum at Fullerton; IX-1-2009, Ips, W. Knudson; Ibid. IX-29-2009; Ibid.X-12-2009, Sirex.

Los Angeles Co., Huntington Library, San Marino, IX-2-2009, Ips, W. Knudson.

Dactylotrypes longicollis (Wollaston) from Fullerton, San Diego County. Emergence holes from Brazilian Needle Palm seeds (*Trithrinax acanthocoma* Arecaeae) from Fullerton, California.

Araptus schwarzi (LeConte)

Several specimens of a new scolytid beetle were found in Lindgren Funnel traps baited with manuka oil as part of the Redbay Ambrosia Beetle survey.

The species is known from Mexico, Ecuador, and Costa Rica.

James LaBonte, Oregon Department of Agriculture, provided the initial identification. Final confirmation was provided by Robert Rabaglia, US Forest Service, Arlington, VA.

This is a first United States record of this species. Known host is avocado and was reared from seeds from which the flesh had rotted away.

Records: San Diego Co., Escondido.

Araptus swharzi (LeConte) from Escondido, San Diego County. New North American record.

Establishing Background Data to Evaluate the Impact of *Mecinus janthinus* in California

Dale M. Woods, G. F. Hrusa[1], Chris Hon[2], and Viola Popescu

The toadflax stem weevil, *Mecinus janthinus*, has been reported to be one of the more successful biological control insects released in North America in recent years. The first permitted releases in California were in May and June of 2008 in the Hungry Valley State Vehicular Recreation Area in Southern California. This site is one of a handful in Southern California, all which are over 200 miles from the other Dalmation toadflax infestations in California, and is more southern than any other release site in North America. This location is also one of the finest (and most popular) wildflower viewing locations in California. By releasing the weevils at this site, we hope to document a substantial impact on the exotic and invasive toadflax, and simultaneously demonstrate positive effects on the other plants and wildflowers in the region.

Six locations in a heavily infested valley within the Recreation Area were chosen for monitoring. Weevils were released near three of these sites with the remaining three sites selected as 'no-release' controls. Larva and adult weevils along with evidence of tunneling activity were detected at the release locations in the fall of 2008, 2009 and again in 2010. The three control sites have remained weevil free.

A permanent field transect was set up in each location in 2008. Each transect has 20 quadrats (0.5 m by 0.5 m) that are regularly monitored. Therefore, a total of 60 quadrats are monitored in the weevil free area and 60 in weevil areas. In late-spring of years 2008-2010, plant 'cover' evaluations were made. For each quadrat, coverage by plant species was determined with a rating system; 0 = no coverage by the evaluated species; 1 = 1-5% of the quadrant was covered by the selected species; 2 = 5-25%; 3= 25-50%; 4 = 50-75%: and 5 = >75%. For analysis, each reading was given the mid-point value for the category, e.g. 1 = 2.5%.

Figure 1. One of the transects in Hungry Valley SVRA where cover estimate were made.

The winter of 2007-08 preceding our first release and cover reading was very wet and most plant species in the area benefited. During our spring 2008 evaluations, plants were taller and more vigorous than previous monitored years. Additionally, a large number of plant species emerged that year including some dramatic and showy wildflowers. The detected plant species are listed in Table 1. The years 2009 and 2010 were more traditional in terms of moisture. It will be essential to continue long-term monitoring in order to separate effects of the biological control agents from the effects of yearly weather variation The calculated cover for the most abundant species are shown in Figure 2. During the short monitoring period so far, there were no distinct impacts on Dalmation toadflax 'cover' in spite of high attack rates. Based on observations in

other states, impacts may be anticipated within the next few years. There were also no clear cut impacts on the grass species or on the predominant native dicots. One unexpected and unfortunate variable emerged in the data - significant differences in grass communities exist between the release sites and the non-release sites. Foxtail fescue (*Vulpia myuros*), was the predominant grass on the release sites with Downy brome (*Bromus tectorum*), and Pine bluegrass (*Poa secunda*), more predominant in the control ("no-release") sites.

Table 1. Preliminary identifications of plant species present in the monitored transects at Hungry Valley State Vehicular Recreation Area. Taxonomic treatment conforms to The Jepson Manual.

	Control sites			Release sites			Native
Plant species	2008	2009	2010	2008	2009	2010	
Linaria dalmatica	X	X	X	X	X	X	No
Grasses							
Avena barbata				X	X	X	No
Bromus madritensis ssp. *rubens*			X			X	No
Bromus tectorum	X	X	X	X	X	X	No
Elymus multisetus	X	X	X	X	X	X	Yes
Poa secunda	X	X	X	X	X	X	Yes
Vulpia microstachys var. *ciliata*						X	Yes
Vulpia myuros	X	X	X	X	X	X	No
Forbs							
Androsace elongata	X	X	X	X	X	X	Yes
Artimisia tridentata				X			Yes
Athysanus pusillus		X		X	X	X	Yes
Calochortus sp.	X		X				Yes
Ericameria sp.			X	X		X	Yes
Eriogonum pusillum			X				Yes
Erodium cicutarium	X	X	X	X	X	X	No
Eschscholzia californica	X	X	X	X			Yes
Gilia sp. #1					X		Yes
Gilia sp. #2				X	X		Yes
Juniperus californica	X	X					Yes
Lagophylla ramosissima	X	X	X	X	X		Yes
Lessingia filaginifolia	X	X	X	X	X	X	Yes
Lupinus bicolor				X	X		Yes
Madia sp.		X			X		Yes
Microseris lindleyi	X	X	X	X	X	X	Yes
Phlox gracilis		X		X	X		Yes
Phacelia imbricata	X	X	X	X	X	X	Yes
Plagiobothrys arizonicus	X	X	X	X	X	X	Yes
Stephanomeria pauciflora	X	X	X	X	X	X	Yes
Thysanocarpus curvipes			X				Yes

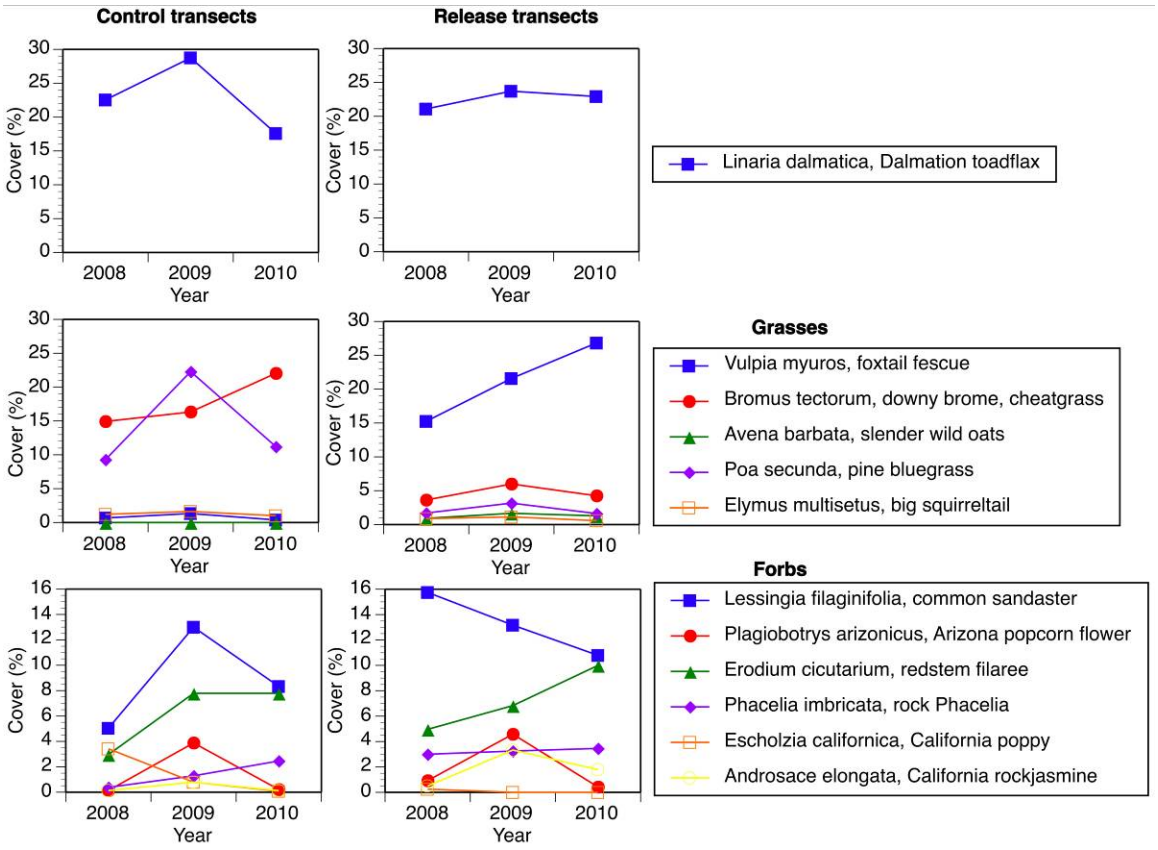

Figure 2. Mean cover ratings for the most common plant species at the toadflax biological control portion of Hungry Valley State Vehicular Recreation Area.

[1]CDFA, Plant Pest Diagnostics Laboratory, Sacramento, California
[2]California State Parks, Gorman, California

First Release of a Biological Control Agent for *Arundo donax* in California

Dale M. Woods, John Goolsby[1], Ray Harrie[2], David Spencer[3], Claudia Street[4],
Baldo Villegas, and Marilyn Vernon[5]

Giant reed, *Arundo donax*, is a highly invasive, ecosystem dominating riparian weed impacting California and elsewhere in the southwest United States and Mexico. Because of the difficulties controlling this invader with herbicides and /or cultural methods, biological control is being attempted using a suite of natural enemies. The first natural enemy of giant reed to be approved for release in North America is a small stem-boring wasp, *Tetramesa romana*. The United States Department of Agriculture, Agricultural Research Service's Beneficial Insects Research Unit in Weslaco, Texas, has been rearing and evaluating several biotypes of the wasp that were collected at various locations in Europe. Each biotype was selected from locations with specific environmental parameters, specifically, daily temperature variation. The first releases were made and confined to the Rio Grande in Texas beginning in 2009.

Two biotypes were selected for release in Northern California based on comparisons of climate to the original selection site. Individual biotype cultures of *T. romana* were reared at the Weslaco facility. Short stems with galls (12-14 inches in length) were shipped to California for release. Each galled stick was taped to young stems of *A. donax* in the field, and the galled sticks left to allow emergence of adult wasps.

Figure 1. Emergence holes of *Tetramesa romana* on *Arundo* galled sticks of *A. donax* sent from USDA-ARS in Texas.

Figure 2. Release site #1 in Glenn County.

Santa Caloma Biotype

The first release was of the Santa Caloma biotype, originally collected near Barcelona Spain. Climate matching suggested that this biotype would be well suited to the interior Sacramento Valley. Thirty galled sticks were spread in three separate clumps of Arundo along Stony Creek, near Orland in Glenn County on July 29, 2010. Galled sticks were retrieved on August 17 and dissected to determine the number of larval chambers in the galled sticks and thus estimate the number of adult wasps that had emerged (Table 1).

Perpignan Biotype

The second rounds of releases were of the Perpignan biotype, originally collected near Perpignan, France. Climate matching suggested that this biotype would be well suited to the San Francisco Bay region. Releases were made in three counties Thirty galled sticks were spread in clumps of Arundo along Sonoma Creek, in Sonoma County on November 8, 2010, and another 63 were placed at the Aquatic Weed Research Lab near Davis California. On November 15, the final 15 galled sticks were placed along River Road near Hopland in Mendocino County. Ten sticks were retrieved from the Davis site on December 7 and dissected to determine the number of larval chambers and thus estimate the number of adult wasps that had emerged (Table 2). The remaining galls at Davis will be left until spring, as will the galls at Sonoma and Mendocino.

Figure 3. Mendocino County release site.

We estimate that between 13 and 15 live adults emerged on average from each galled stick at the Glenn County release of the Santa Caloma biotype. A few insects died as adult in the galls as the galled sticks dried out, and some emergence holes seem to have been used by multiple insects. We re-visited the sites several times and on December 16 found emergence holes and live larvae within chambers on extant plants at two of the sites. Therefore, it appears that the wasps have completed at least one generation on the naturalized host in Glenn County. Confirmation of overwintering will be pursued in the spring.

Table 1. Dissection results of released galled sticks from the Glenn County site.

Site	Replicate stick	Exit holes	Chambers	Larvae	Dead adults	Live adults released (est.)
Site 1	1	0	5	0	0	5
	2	17	24	0	7	17
	3	21	25	0	4	21
	4	21	33	0	3	30
	5	19	12	0	3	9
Site 2	1	20	23	0	0	23
	2	17	21	0	2	19
	3	12	15	0	1	14
	4	17	17	0	0	17
	5	8	14	0	2	12
Site C	1	12	14	0	1	13
	2	0	0	0	0	0
	3	18	18	0	0	18
Average		13.1	15.6		2.3	15.2

The galled sticks from the Perpignan release seem even more infested than the Santa Caloma release. However, the majority of these were still immature (live larva in the galls) at the time of recollection. Presumably, the cold weather at this time will prevent maturation and galls remaining in the field will be a source of overwintering.

Table 2. Dissection results of released galled sticks from the Yolo County (Davis) site.

Site	Replicate stick	Exit holes	Chambers	Larvae	Dead adults
Site 1	1	1	1	1	0
	2	1	4	1	0
	3	0	4	5	0
	4	0	40	38	0
	5	3	22	17	0
	6	6	9	5	0
	7	8	15	4	0
	8	4	38	28	0
	9	3	36	24	0
	10	9	38	23	0
Average		3.5	20.7	14.6	0

Figure 4. Emergence holes of *Tetramesa romana* in naturalized *Arundo donax* in Glenn County.

[1] USDA-ARS, Beneficial Insects Research Unit, Weslaco, Texas
[2] Mendocino County Department of Agriculture, Ukiah, California
[3] USDA-ARS, Aquatic Invasive Weed Research Unit, Davis, California
[4] Glenn County Resource Conservation District, Willows, California
[5] Sonoma County Department of Agriculture, Sonoma, California

Plant Material for Pre-release Host Testing of Potential Biological Control: California 2010

Dale M. Woods, Viola Popescu, Robert Price[1], G. F. Hrusa[1], Dean Kelch[1], Baldo Villegas

Pre-release host-testing is a critical component in establishing a biological control program. Soon after a potential natural enemy is identified, the arduous task of insuring safety for agricultural crops and native species is initiated by testing the proposed agent on representative non-target species. This testing is usually performed overseas and/or in domestic quarantine facilities. Commercial crops that are related to the target weed or otherwise at risk are identified and tested. The more complex issues often relate to the many native plant species related to the target weed. With perhaps the highest diversity of plants in the United States, California is home to a large number of species of concern. Several noxious weeds that occur in California are targets of biological control efforts. It is critical that non-target test species are supplied to researchers so that progress in the testing of biological control agents occurs swiftly. In 2010, we collected and/or purchased a large number of plant species material for eventual testing for host acceptability for four projects that are in various stages of progress. Based on an existing 'proposed host test list', we located many of the requested test species, ensured their appropriate identification, collected seeds or entire plants, and provided the material to cooperators for host testing. In some instances, alternative plant species were identified and used in place of uncollectable material. Plant materials collected for the four projects are listed below.

Cape-ivy project

Cape-ivy (*Delairea odorata)*, also known as German ivy and *Senecio mikanioides,* is primarily a pest of natural areas. Its ability to engulf other vegetation in coastal areas make it a highly disruptive invader. This project that was the most progressed of the four projects with very few plant species remaining to be tested. Proposed agents had been tested in quarantine and have been shown to be highly host specific. However, during final review of the release proposal, reviewers felt that a few additional native species groups were underrepresented in the testing. Three species of related *Senecio* were collected and sent to the USDA-ARS quarantine laboratory in Albany, California to complete testing. No additional collections are anticipated for this project.

Table 1 Plant species collected for the Cape-ivy project (names follow Jepson Manual).

Genus	Species	Common name	Native?
Senecio (*Packera*)	*clevelandii*	Cleveland's ragwort	Yes
Senecio	*hydrophilus*	alkali-marsh ragwort	Yes
Senecio	*aronicoides*	California butterweed	Yes

Toadflax project

Toadflax species are highly invasive and displace native and more desirable vegetation. Host testing for natural enemies of Dalmatian toadflax (*Linaria genistifolia* ssp. *dalmatica*) has been ongoing for many years. Several biological agents have been approved and released elsewhere in North America but only one species (*Mecinus janthinus*) has been released in California. Additional natural enemies are currently undergoing evaluation at CABI-Europe. California has a high diversity of native plants related to Dalmatian toadflax, some of which

were underrepresented in earlier years of host testing. Additionally, potential biological control agents are being evaluated for the related species, yellow toadflax (*Linaria vulgaris*). Consequently, we attempted to support this effort by collecting or purchasing appropriate native species that had not been evaluated. These were provided to CABI for host testing. The 2010 collection efforts are listed in Table 2. A limited number of species remain to be collected.

Table 2. Plant species collected for the toadflax project (names follow Jepson Manual).

Genus	Species	Common name	Native?
Linaria	*genistifolia* ssp. *dalmatica*	Dalmation toadflax – Trinity County	No
Linaria	*genistifolia* ssp. *dalmatica*	Dalmation toadflax – Kern County	No
Bacopa	*rotundifolia*	round-leaved water hyssop	No
Scrophularia	*californica*	California bee plant	Yes
Tonella	*tenella*	lesser baby innocence	Yes
Trichostema	*lanatum*	woolly bluecurls	Yes
Valeriana	*californica*	California valerian	Yes
Verbena	*lasiostachys*	western vervain	Yes

Bindweed project

Field bindweed, *Convolvulus arvensis*, is one of the world's most important weed. In California, it is a serious problem in commercial agriculture, roadsides and natural areas. The biological control effort against field bindweed began in the 1970s, with two biological control agents released in the Midwestern U.S. (not in California). The gall mite, *Aceria malherbae,* became established but the impact to date is highly variable. Establishment of the bindweed moth, *Tyta luctuosa*, has never been confirmed. In 2009, evaluations began on two additional biological control agents. California has a large number of native plants related to field bindweed, some of which are endemic to the state. We attempted to support this effort by collecting or purchasing appropriate native species for host testing at CABI. A limited number remain to be collected.

Table 3. Plant species collected for the bindweed project (names follow Jepson Manual).

Genus	Species	Common name	Native?
Calystegia	*occidentalis* ssp *fulcrata*	Sonora morning glory	Yes
Calystegia	*macrostegia*	island morning glory	Yes
Calystegia	*occidentalis*	Chaparral false bindweed	Yes
Calystegia	*purpurata*	Pacific false bindweed	Yes
Calystegia	*sepium* ssp. *limnophila*	Hedge bindweed	Yes
Calystegia	*subacaulis* ssp. *subacaulis*	stemless morning glory	Yes
Calystegia	*soldanella*	beach morning glory	Yes
Dichondra	*donnelliana*	California ponysfoot	Yes
Convolvulus	*arvensis*	3 collection locations	No

Brassica project

The Brassica project is a new and very large project centered around four species of weedy mustards. These include two species of hoary cress (whitetop): heart-podded hoary cress (*Lepidium draba* also known as *Cardaria draba*) and globe-podded hoary cress (*L. appelianum*

also known as *Cardaria pubescens*); perennial pepperweed (*L. latifolium*), and dyer's woad (*Isatis tinctoria*). All are exotic invasive species in California, however, perennial pepperweed is the most invasive and widespread in California. As a new project that is addressing four weed species, a larger number of plant species is being considered for host testing. We collected or purchased several species and sent them to CABI for host testing. This collection will also be used in evaluations of a naturally occurring plant pathogenic species of *Albugo*. A limited number of species remain to be collected.

Table 4. Plant species collected for the Brassica project (names follow Flora North America).

Genus	Species	Common name	Native?
Alyssum	*desertorum*	desert alyssum	No
Alyssum	*simplex*	Alyssum	No
Arabis	*blepharophylla*	California rockcress	Yes
Barbarea	*orthoceras*	American wintercress	Yes
Boechera	*platysperma*	broad seeded rock cress	Yes
Boechera	*pulchra*	Prince's rock cress	Yes
Boechera	*rectissima*	bristlyleaf rockcress	Yes
Cardamine	*breweri*	Brewer's bittercress	Yes
Cardamine	*oligosperma*	bittercress	Yes
Cardamine	*nuttallii*	Nuttall's toothwort	Yes
Caulanthus	*coulterii*	Coulter's jewel flower	Yes
Caulanthus	*inflatus*	desert candle	Yes
Caulanthus	*pilosus*	hairy wild cabbage	Yes
Descurainia	*californica*	Sierra tansy mustard	Yes
Descurainia	*pinnata*	yellow tansy mustard	Yes
Descurainia	*sophia*	flix weed	No
Draba	*verna*	Whitlow grass	Yes
Erodium	*cicutarium*	redstem filaree	No
Lepidium	*flavum*	yellow pepperweed	Yes
Lepidium	*fremonti*	desert pepperweed	Yes
Lepidium	*lasiocarpum*	shaggyfruit pepperweed	Yes
Lepidium	*latipes*	San Diego pepperweed	Yes
Lepidium	*nitidum*	common peppergrass	Yes
Lepidium	*strictum*	upright pepperweed	Yes
Lepidium	*oxycarpum*	forked pepperweed	Yes
Lepidium	*virginicum*	Virginia pepperweed	Yes
Limnanthes	*alba*	white meadowfoam	Yes
Lunaria	*annua*	annual moonwort	No
Nasturtium	*officinale*	watercress	Yes
Planodies (Sibara)	*virginica*	Virginia winged rockcress	Yes
Rorippa	*columbiae*	Columbia yellowcress	Yes
Rorippa	*curvisiliqua*	western yellowcress	Yes
Stanleya	*elata*	Panamint princesplume	Yes
Streptanthus	*farnsworthianus*	Farnsworth's jewelflower	Yes
Streptanthus	*polygaloides*	milkwort jewelflower	Yes
Streptanthus	*tortuosus*	mountain jewelflower	Yes
Thysanocarpus	*curvipes*	lace pod	Yes

Table 4 (continued) Plant species collected for the Brassica project (names follow Flora North America).

Genus	Species	Common name	Native?
Collected did not send			
Boechera	*holboellii var ?*		Yes
Boechera	*retrofracta*	backward splitting Holboell's rock cress	Yes
Boechera	*sparsiflora*	elegant rock cress	Yes
Boechera	*subpinnatifida*	Klamath rockcress	Yes
Cardamine	*californica*	milk maids	Yes
Erysimum	*asperum*	great plains wallflower	No
Erysimum	*capitatum*	western wallflower	Yes
Lepidium	*campestre*	field pepperweed	No
Lepidium	*perfoliatum*	clasping pepperweed	No
Sisymbrium	*altissimim*	tumble mustard	No
Thlaspi	*arvense*	field pennycress	No

Figure 1, Top row, left to right – Field collected *Boechera* sp.; reproductive parts after stems are removed; seeds amid debris
Bottom row, left to right – wire mesh sieves; sieved seed and small debris; nearly clean seed.

[1]CDFA, Plant Pest Diagnostics Laboratory, Sacramento, California

Long-term Population Maintenance of *Larinus curtis* in California

Dale M. Woods and Viola Popescu

The yellow starthistle flower weevil, *Larinus curtus*, Hochhut (Coleoptera: Curculionidae), was first released in California and other western states in 1992. It was the last biological control agent introduced that focused on the seedheads of yellow starthistle. It is active at a slightly different time (full flowering) than the other starthistle biological controls, and is a strong flier. It was expected to attain a small but significant role as part of the guild of insects attacking this weed species. One of the earliest releases of *L. curtis* was at Sugarloaf Ridge State Park in Sonoma County in 1993. All of the available starthistle biological control agents were also released at this location. This report focuses on the long-term persistence of *L. curtis* at this site as part of the complete suite of agents on yellow starthistle.

Permanent transects were established within a heavily starthistle-infested meadow surrounded by oak and pine foothills. All seedheads on selected plants were 'bagged' with small cotton bags each year to contain developing seeds and any biological control agents. Detection of *L. curtis* has been based on both field observations and on seedheads dissected each year. Dissection results have shown a very small(<3%) degree of attack by *L. curtis* (Figure 1). Unlike the other seedhead biological control agents, *L. curtis* does not produce a single definitive damage feature in the seedheads of yellow starthistle. If the weevil matures to adulthood within the seedhead, the determination is certain, if not, then the determination is made by by a combination of present and not-present features. Consequently, the number of attacks made by *L. curtis* may be slightly under-estimated but not greatly so. Adult weevils have been easily detected in the field every year at levels higher than the seedhead dissections would suggest. Adult weevils seem to congregate on low density, large size plants that are near a small stream at this site.

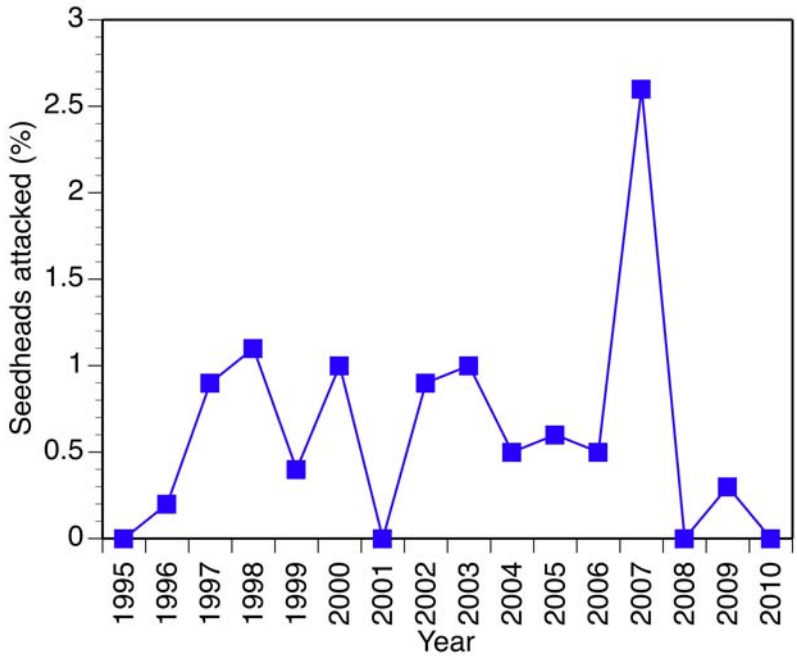

Figure 1. Seedheads of yellow starthistle attacked by *Larinus curtis*

In spite of the limited role that *L. curtis* is playing at this site, yellow starthistle is highly attacked by biological controls (Figure 2). The most significant agent at this site has been the hairy weevil, *Eustenopus villosus*. A third weevil, the bud weevil, *Bangasternus orientalis*, has gradually declined in significance and has not been found since 2005. *Chaetorellia succinia* and *Urophora sirunaseva* each attack between 1-25% of the seedheads each year. The rust fungus, *Puccinia jaceae* var. *solstitialis,* has not established.

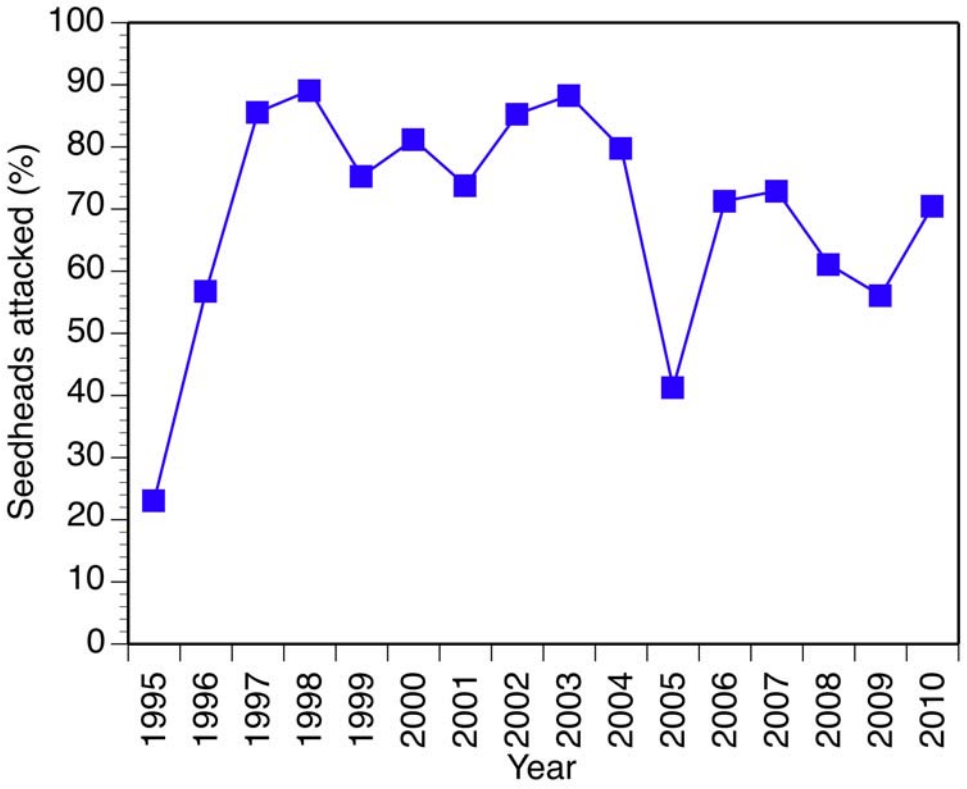

Figure 2. Seedheads of yellow starthistle attacked by any biological control agent.

Biological Control of Rush Skeletonweed, *Chondrilla juncea* L. (Asteraceae) in San Mateo County, California

Baldo Villegas

Rush skeletonweed occurs in several counties in California and in the past has been the target of biological control as well as eradication measures by the California Department of Food and Agriculture. Three biological control agents have been introduced into California. They are; a gall midge, *Cystiphora schmidti*; a gall mite, *Eriophyes chondrillae* (Figure 1); and a rust fungus, *Puccinia chondrillina* (Figure 3). These biological control agents were widely distributed in the 1970's through the early 1980's resulting in various levels of biological control in areas where the agents became established. Since that time, rush skeletonweed has continued to be spread to new areas in California and either eradicated or kept under control by herbicide treatments.

In July 2010, San Mateo County requested that a biological control project be started in the urban areas of the county infested with skeletonweed. A quick survey of the area revealed the presence of the rust fungus and the absence of gall midge and the gall mite. The rust fungus was found on the stems at all three areas surveyed (Figure 3). Presumably, the fungus moved there on its own as has happened with other species of rust fungi that have been released as biological control agents.

In early August, the only available biological control agent for re-distribution was the skeletonweed gall mite. This microscopic eriophyiid mite causes galls new growth associated with the reproductive parts of the skeletonweed plants affecting seed production. Depending on the infection level, plants that are infected by the mites produce much less seed than healthy plants. On August 10, 2010, severely infested plants were collected in the Loomis area of Placer County and transported to San Mateo County for release of the gall mites at three sites. Approximately 150 galled stems (Figure 1) infested with the gall mites were separated from the heavily galled plants, placed in plastic containers, and taken to the three sites for release onto actively growing plants. The gall mites were released by placing two to four galled stems in the middle of actively growing skeletonweed plants growing along the shoulder and sidewalks of a major street in San Carlos, California (Figure 2). There were 12-15 releases of the gall mites at each of the three sites. Groups of skeletonweed plants growing in close proximity to each other were given the higher priority than releasing the galled stems on single plants.

Figure 1. Galled stem caused by the skeletonweed gall mite and placed in actively growing skeletonweed plants in San Carlos, California.
Figure 2. San Mateo County agricultural biologists placing galled stems in a cluster of plants along a street shoulder site in San Carlos, California.
Figure 3. Skeletonweed rust on the lower stems of many plants in the San Carlos area infestations.

Figure 4. Recovery of the gall mite in a skeletonweed plant at a release site in San Carlos, California.

The release sites were visited on September 21, 2010 and January 26, 2011 in order to record recoveries at the release sites. Individual plants were inspected for the formation of galls as a 'present/absent' survey in the individual plants. At the first site, 38 of 45 plants were found to have galls. This site contained several clusters of plants and the mites were found in most plants within the cluster of plants. At the second site, the plants were more widely spaced and there were very few clusters of plants. A total of 107 plants were checked and 37 plants were found with galls. Of the galled plants, 23 were found in the three clusters of plants. The other 14 galled plants were found singly at the site. Galled plants were found at the third release site but a survey was not conducted as many of the plants had been cleared by the property owners.

Biological Control of Purple Loosestrife in Fresno County

Baldo Villegas

The two leaf beetles, *Galerucella pusilla* and *G. calamarense*, have become well established in Shasta and Butte County and have started to impact stands of purple loosestrife. However, in Fresno County, the same beetles have been difficult to get established. Past releases have been done using adult beetles collected in June, August and early September from the McArthur area of Shasta County. During the 2010 season, a different strategy was attempted using younger, less developed individuals to see if the beetles would become established. Approximately 6,000 first generation beetles were mass collected in the Palermo area of Butte County on June 2 and released the following day at an area outside of Sanger, California (Fresno County). The beetles collected consisted largely of late instar larvae and about 10% adults. Two sites were selected about a quarter of mile from each other. One release was made at a creek that drains into the Kings River and the other release was made around a large acre pond at a nearby ranch (Figure 1). About 1000 beetles were released at five subsites around the pond.

The two sites were monitored three times from July to October 2010 for establishment of the beetles. During each visit at the pond site, visible damage corresponding to two beetle generations were noted at all subsites. At this pond site, *Galerucella* larvae and adults were common in July and September and became less common during the October monitoring visit. At the creek site, larval damage was seen during the July monitoring visit but no larvae or adult beetles were recorded in September or in October. The lack of recoveries at this site was probably due to large number of ants on the loosestrife plants. The ants were present around the pond but at lower numbers.

Figure 1 Pond infested with purple loosestrife near Sanger, California.
Figure 2 Feeding damage by the *Galerucella* beetle larvae. Similar damage was noted at all released sites around the pond.

A Case of Fortuitous Biological Control of Dalmatian Toadflax in Susanville

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In August 2010 two seasonal employees, Al Howe and Kim Olsen, of the Lassen County Department of Agriculture found a stem-boring weevil to be very common in stems of Dalmatian toadflax in Susanville, California. They were dissecting the stems in order to evaluate the efficacy of their herbicide treatments of this invasive weed. The weevil was subsequently identified as *Mecinus janthinus* Germar (Coleoptera: Curculionidae) by Dr. Andrew Cline (Systematic Entomologist, CDFA Plant Diagnostics Laboratory). This weevil is currently used in several states in the United States as a biological control agent for Dalmatian toadflax, *Linaria dalmatica* (L.) Mill. (Scrophulariaceae). The weevil had not been released in any of the Northern California Dalmatian toadflax infestations due to concerns that this weevil might feed on native *Antirrhinum* snapdragons in some parts of California. Consequently, two surveys were initiated to evaluatre the presence of the weevil locally. The first survey focused on visiting known infestations of Dalmatian toadflax in Northern California for the presence or absence of the weevil. The second survey was designed to infer how long the weevil had been in the Susanville area.

The first survey (presence/absence) was actually an acceleration of an ongoing regional survey that had for several years been unable to detect any weevil findings. In 2010, areas of Lassen, Modoc, Siskiyou, and Trinity counties were surveyed. Table 1 lists the sites visited for this survey. No weevils were found outside of the Susanville area of Lassen County.

Table 1: Dalmatian Toadflax Survey - 2010

Location	County	Date	Mecinus Weevils Present?
Susanville (Skyline Park)	Lassen	September 1, 2010	Yes
Susanville (Mounds)	Lassen	September 2, 2010	Yes
Susanville (Rancheria)	Lassen	September 2, 2010	Yes
Susanville (Water tank)	Lassen	September 2, 2010	Yes
Susanville (Inspiration Pt)	Lassen	September 2, 2010	Yes
Susanville (Biz Johnson Tr)	Lassen	September 2, 2010	Yes
Susanville (Hobo Camp Rd)	Lassen	September 2, 2010	Yes
New Pine Creek	Modoc	June17, 2010	No
New Pine Creek (6 sites)	Modoc	September 2, 2010	No
Mount Shasta (2 sites)	Siskiyou	July 28, 2010	No
Butte Valley (multiple sites)	Siskiyou	July 27, 2010	No
Tennant	Siskiyou	October 27, 2010	No
Big Bar	Trinity	November 17, 2010	No
Junction City	Trinity	November 17, 2010	No
Lewiston	Trinity	November 17, 2010	No

For the second survey, the Susanville area was surveyed along with Al Howe and Kim Olsen on September 2, 2010 (Figure 1). During this survey, multiple stems from at least 10 plants were dissected. The weevil was found at all major Dalmatian toadflax infestations around the Susanville area (Table 1). From this survey, we believe that the weevils have been in the

Susanville area since at least 2009, possibly earlier. This conclusion is based on the weevils' life history. During the September, November, and February visits, the weevils were found overwintering in the stems as adults. According to the literature, the weevils will overwinter in the stems until the spring and will emerge from the stems as the temperatures warm up and the plant breaks from dormancy to push new growth from the overwintering rosettes (Figure 3). The weevils then emerge and start feeding on the plant tissue, mate, and the females start oviposition on the stems (Figure 2). The adult weevils eventually die off in early summer. Their larvae emerge from the eggs soon after oviposition and feed inside the stem generally within an inch of where the egg was laid. If the weevils are found in large numbers, numerous eggs are laid on each stem all the way to the tips of the infloresence. The weevil larvae go through several instars and eventually turn in to a pupae. When the weevils were first found in mid August 2010, the weevils were found in the pupal stage and on September 1-2, all weevils found inside the stems were in the adult stage.

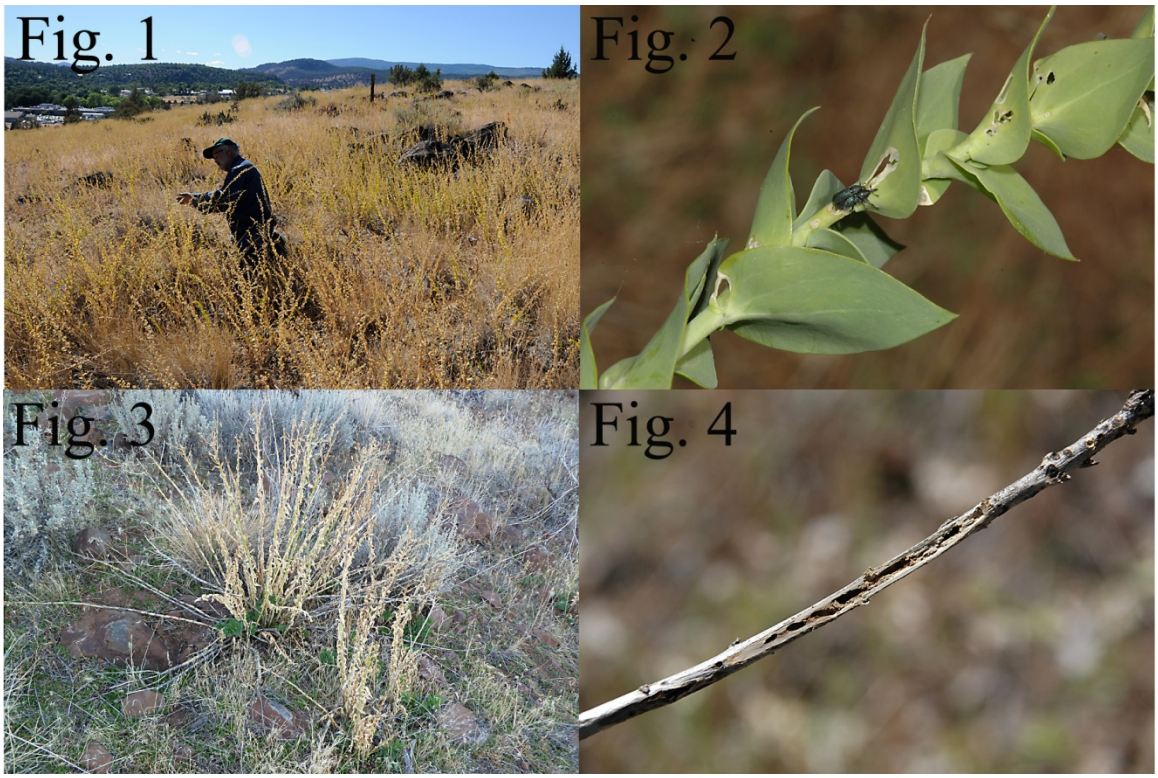

Figure. 1: Dalmatian toadflax infestation at Skyline Park, Susanville, California.
Figure. 2: *Mecinus janthinus* weevils and feeding damage to toadflax stem.
Figure. 3: Typical toadflax plants showing new and old growth.
Figure. 4: Old toadflax stem showing weevil emergence holes and tunneling damage.

In our comprehensive survey on February 2, 2011, three main sites were visited and a total of 30 plants were studied at each site. At each site, a 30 meter tape was used for a transect with plants closest to the meter mark being chosen. All the stems on each plant chosen were aged by the year it was produced and then determined if the stem had been damaged by the weevil or

not. Determining the age of stems before 2008 was difficult as most stems become aged, fragile and easily fell apart. However, we were able to make several conclusions from the data gathered. From these data, we conclude that the weevil probably came into the northern area of Susanville in about 2008 or earlier. It was also noted, that in areas where the weevil had been damaging plants since 2008, the plants had ceased seed production, and started to die off.

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(names in **Bold** are part of the CDFA Biological Control Program)

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