1. Summary

Project Title: Egg parasitism of the Virginia creeper (*Erythroneura ziczac*), a newly invasive leafhopper pest in California.

Principal Investigators: Kent Daane, Glenn McGourty, Serguei Triapitsyn, Lucia Varela

Summary:

Grape growers in Mendocino/Lake County are experiencing outbreaks of the Virginia creeper leafhopper (*Erythroneura ziczac*) [Hemiptera: Ciccadellidae]. Feeding by *E. ziczac* causes leaf stippling, loss of photosynthetic capacity and can ultimately reduce crop yield and quality. This leafhopper is also thought to transmit the newly discovered grapevine virus "Red Blotch Disease". The primary egg parasitoids of the Virginia creeper leafhopper (VCLH) are *Anagrus daanei* and *Anagrus tretiakovae* [Hymenoptera: Mymaridae]. A related vineyard pest, the Western grape leafhopper (*Erythroneura elegantula*, WGLH) is also parasitized by *A. daanei* as well as *Anagrus erythroneurae*. VCLH and WGLH are commonly found together in many North Coast vineyards. In California, *A. daanei* is the parasitoid species of most importance for VCLH control, as *A. tretiakovae* has never been found in California.

Over the past year we focused on determining parasitism levels and parasitoid species present in vineyards infested with VCLH and WGLH. Mendocino County surveys found that VCLH parasitism was practically non-existent while parasitism of WGLH eggs occurred with relatively high frequency. We isolated and reared the *Anagrus* species attacking WGLH eggs in these vineyards and found 87% *A. erythroneurae* and 13% *A. daanei*. While *A. daanei* is known to attack both WGLH and VCLH eggs, they are only attacking WGLH in Mendocino County. We subsequently reared *Anagrus* specimens from parasitized VCLH eggs from a vineyard in Yolo County. These specimens were identified as *A. daanei*. This finding brings into question the *A. daanei* populations found in these two counties – why is *A. daanei* attacking VCLH in Yolo, but not in Mendocino County? We will address this with our work in 2014.

We sampled for *Anagrus* and leafhopper species in the natural and cultivated habitats surrounding North Coast vineyards. While *A. erythroneurae* could be found on many host plants, we found *A. daanei* was very restricted in host diversity and overall in low abundance, which could explain the lack of VCLH parasitism. While we did find small populations of VCLH and WGLH on a variety of non-crop plants during the growing season, both pests appeared to overwhelmingly prefer cultivated grapes during the growing season and in the winter reside in vineyard leaf litter. The most common non-crop host was wild grape and VCLH actually appears to be reproducing on it. Work in 2014 will further evaluate VCLH use of wild grapes as refugia and reproductive sites.

We conducted a spray trial to determine effectiveness of OMRI approved products for VCLH control. Three insecticides were tested: Pyganic®, Mycotrol® and Grandevo™. Application timing was scheduled to target young leafhopper nymphs (mid-June). Pyganic® significantly reduced nymph populations compared to the control while Mycotrol® and Grandevo™ were not significantly different from the control after the first or the second application. Further trials are planned in 2014 to evaluate application timing and frequency for non-OMRI products.

2. Annual or Final Report
This is an annual report (year 1)

3. Project Title and UGMVE proposal number
"Egg parasitism of the Virginia creeper (*Erythroneura ziczac*), a newly invasive leafhopper pest in California." (Proposal #2014-1493)

4. Principle Investigator/Cooperator(s):
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5. Objective(s) and Experiments Conducted to Meet Stated Objective(s):
1. Determine leafhopper egg parasitism levels and parasitoid species present in vineyards infested with Virginia creeper and Western grape leafhopper species.

1a. Determine leafhopper egg parasitism levels.
We identified 3 vineyard sites in Mendocino County with extensive outbreaks of VCLH and WGLH. In early August we collected 30 leaves from nodes 4-6 on the grape vine shoots at each site. Leaves were brought back to the lab and examined with a dissecting microscope to determine frequency of egg parasitism. Leafhopper eggs were differentiated by the fact that WGLH lay eggs singly while VCLH typically oviposit in clutches of 2-10 eggs (Fairbairn 1928, Wells and Cone 1989). In some rare cases VCLH eggs were laid singly, but could still be differentiated from WGLH by a light gray/blue discoloration that occurs around VCLH eggs. Parasitism was determined by either presence of circular parasitoid exit hole or if there was a clearly visible parasitoid developing within the egg. Paired t-tests were used to evaluate differences in parasitism frequency between VCLH and WGLH.

In a related effort, we also evaluated VCLH and WGLH egg deposition on different grape varietals. Previous studies have indicated that VCLH tend to prefer more glabrous grape leaves with a lower trichome density (McKenzie and Bierne 1972). In the field we noticed that populations of Virginia creeper leafhopper were higher on some varieties. For example, in side-by-side Grenache and Zinfandel blocks, populations were very high on the Grenache block, with no damage on the adjacent Zinfandel block. One difference between these two varieties is that

Grenache is glabrous (no trichomes) on the lower surface of the leaf while Zinfandel has a high density of trichomes (tomentose). We selected three varieties with different densities of trichomes on the lower surface to determine if hairiness may be a factor in the different levels of VCLH populations. The three varieties selected were Tinta Francisca (glabrous), Amarela (moderately tomentose) and Tannat (wooly tomentum). The Hopland varietal trial is replicated with 5 vines of each variety per plot and replicated 8 times. We selected the three varieties from replicate 1, 4 and 8. On September 3, 2013, six leaves (3 from the 1st cluster node and 3 from node 5) were collected from each of three replicates per variety (18 leaves/variety). The number of emerged and viable eggs of VCLH and WGLH were counted per leaf. To account for difference in leaf surface area, each leaf was weighed in grams. The total number of eggs per gram of leaf was calculated by dividing the total number of eggs per leaf by the weight of the leaf. Treatment effects on leafhopper egg counts were analyzed independently by leafhopper species using ANOVA. Tukey's HSD procedure was used to detect treatment differences.

1b. Determine parasitoid species present in vineyards infested with Virginia creeper and Western grape leafhopper species

In early August, 30 leaves were collected from each of 3 heavily infested vineyard sites in Mendocino County. This was to identify the *Anagrus* species attacking WGLH only, since there was zero parasitism of the VCLH at these sites and thus no parasitoids to rear. To identify the *Anagrus* species attacking VCLH eggs we sampled 30 leaves from an infested vineyard in Yolo County where there was evidence of VCLH parasitism. All leaves were brought back to the lab and under the microscope we were able to isolate individual WGLH and VCLH eggs that showed obvious signs of parasitism (clearly visible parasitoid developing within the egg). The parasitoids were then reared out, collected in vials and sent to Dr. Serguei Triapitsyn for identification.

2. Identify Anagrus species collected and reared from leafhoppers on host plants found near vineyards

This effort was augmented by a much larger, on-going collection effort in Napa and Sonoma County carried out by Houston Wilson as part of his doctoral work at UC Berkeley. *Anagrus* overwintering habitat was assessed following methods adapted from Lowery et al. (2007). Study sites consisted of at least 12 separate patches (> 400m^2) of natural and cultivated habitats found near vineyards in Napa and Sonoma County. The same approach was taken in Mendocino County, focusing on 3 primary patches of habitat adjacent to vineyards. The primary natural habitats sampled were oak woodland and riparian, the dominant natural habitats in this study region (Hogg and Daane 2011), but we also included cultivated habitats such as gardens and hedgerows adjacent to vineyards. Each month, from January-May of 2012 and January 2013 - *present*, we sampled vegetation from the various plants that comprise these habitats. Plant material was brought back to the greenhouse and placed into opaque cylindrical paper cartons, where a glass vial was secured to the top of the container to allow light to enter the chamber and attract emerging wasps. Cartons were held under controlled conditions (24ºC, 16:8 h [L:D] cycle, and 40% RH) for 4 weeks to encourage emergence of any overwintering *Anagrus* wasps. Emergence chambers were checked daily. All emerging adult *Anagrus* were collected in the vials and sent to Dr. Serguei Triapitsyn for identification.

Additionally, we used methods following Summers et al. (2004) to sample for VCLH and WGLH populations on the plants in/around infested vineyards starting in August 2013. Our hypothesis was that VCLH could be residing on plants outside of the vineyard and using them as refugia from sprays and/or reproductive sites. The first step was to locate these leafhoppers outside of the vineyard. Study sites include the same habitats used for the *Anagrus* overwintering work. Once a month leafhoppers were sampled off of individual plant species using a D-VAC suction sampling device with a 0.781-ft^2 (0.019 m^2) sampling cone. Each selected plant species in a given habitat was sampled at least 3 times, with each sample consisting of 5 thrusts with the D-VAC. Samples were held in a freezer for 5 days at -20°C and then processed in the lab. All VCLH and WGLH specimens were sorted and identified to species using a dissecting microscope. All other leafhoppers found have been catalogued and saved for further identification as potential alternate hosts for overwintering *Anagrus*.

3. Manipulate parasitoid populations to improve bio-control of Virginia creeper in California.
A preliminary effort was made in the laboratory to introduce live *A. daanei* reared from VCLH eggs collected in Yolo County onto VCLH eggs collected from Mendocino County. Small discs with parasitized VCLH eggs from Yolo County were cut out from a larger grape leaf and placed onto moist cotton in a petri dish. Unparasitized VCLH eggs from Mendocino County were prepared in a similar manner. As the *Anagrus* emerged from the VCLH eggs, we used a paintbrush to transfer the wasps to the other petri dish with VCLH eggs from Mendocino County. In one instance the *Anagrus* appeared to begin parasitizing the VCLH eggs from Mendocino, but results were inconclusive. More experiments are planned for 2014 (see proposal)

4. Determine the effectiveness of OMRI approved insecticides for VCLH control
Note: This was not part of the original proposal but is being included due to its relevance.

The 4 spray treatments consisted of: (1) one Pyganic® application, (2) two Mycotrol® applications, (3) two Grandevo™ applications and (4) an untreated control. Each treatment was replicated four times in a randomized complete block design. Each replicate (plot) encompassed 7 vines; 5 data vines in the center of the plot and one buffer vine on either side. The first application of all three insecticides was on June 11, 2013. On June 27 we made the second application of Mycotrol® and Grandevo™.

Table 1. Application timing and treatment rates

Date	Pyganic®[1]	Mycotrol® O	Grandevo™[2]	Control
	------------------------rate/acre-----------------------			
June 11	13.5 fl oz	1 qt	3 lb	-
June 27	-	1 qt	3lb	-

[1] Pyganic® solution was acidified to a pH of 6.4 and applied with NuFilm at 12 oz/ac
2 Grandevo included a 90/10 non-ionic surfactant at 0.125% v/v

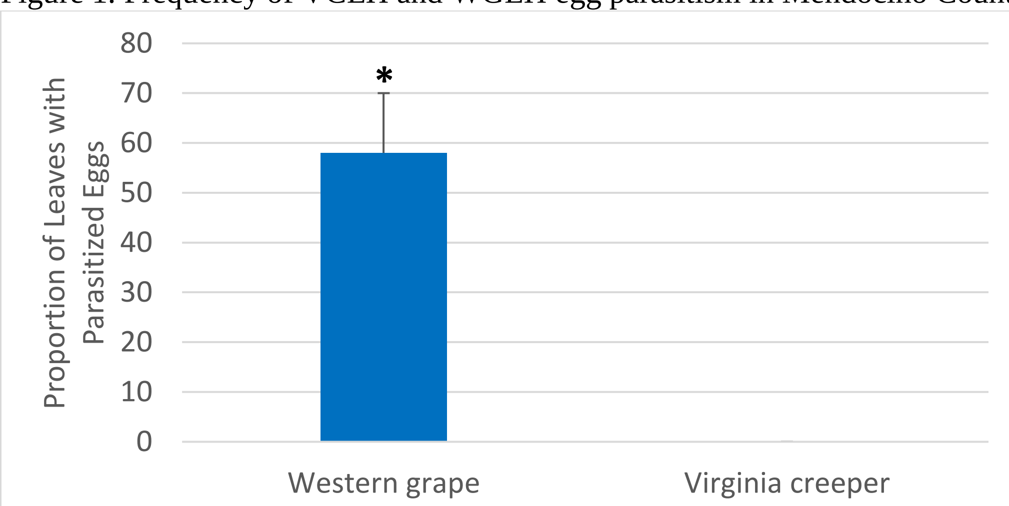
Foliar sprays were applied with a gasoline-powered backpack sprayer at 100 G/ac. A pre-count of leafhopper nymphs was made on June 6 prior to any treatments. The number of leafhopper nymphs per leaf was counted on 5 leaves per plot, selecting one leaf from each of the 5 data vines. Since the first brood develops on basal leaves, we selected basal leaves to monitor for nymphs. Nymph counts were conducted twice after the first treatment on June 13 and June 20 and once after the second treatment on July 3. All counts were conducted in the field. Treatment effects on all leafhopper nymph counts were analyzed independently using ANOVA. Tukey's HSD procedure was used to detect treatment differences.

6. Summary of Major Research Accomplishments and Results by Objectives

Objective 1a. Determine leafhopper egg parasitism levels.

Results of our initial survey in Mendocino County indicates that eggs of the WGLH were parasitized on 58% of the leaves examined, whereas 0% of VCLH eggs were ever found to be parasitized (Figure 1; paired t-test, t=4.4421, df=2, p-value=0.04712). In addition, mixed populations of VCLH and WGLH tended to be much more dominated by VCLH. On one hand this could be due to the fact that WGLH is being parasitized by *Anagrus* and VCLH is not. On the other hand, the VCLH may be able to displace the WGLH in their own right. In reality it is likely to be some combination of both factors. In mixed populations, the VCLH tended to dominate on the lower (abaxial) side of the grape leaf and oviposit closer to the petiole and mid-rib while WGLH were relegated to the edges on the top (adaxial) side of the leaf, where leafhopper eggs are more apparent to parasitoids. In the absence of VCLH, the WGLH tended to reside more frequently on the abaxial side of the leaf and, like VCLH, oviposit closer to the petiole and mid-rib of the leaf.

Figure 1. Frequency of VCLH and WGLH egg parasitism in Mendocino County



* = p<0.05

In a related effort, the total number of VCLH and WGLH eggs per gram of leaf significantly differed according to trichome density (see Figures 2 and 3). On September 3 the average number of Virginia creeper leafhopper eggs per gram of leaf was 0.33 for Tannat, 1.47 for Amarela and 7.72 for Tinta Francisca. Tinta Francisca had significantly higher number of eggs per gram of leaf, followed by Amarela, with Tannat having the least. There was no statistical significant difference in the number of Western grape leafhopper eggs per variety with an average of 6 eggs per gram of leaf. Results show that varieties that have no trichomes had a higher density of VCLH eggs while those varieties with tomentum had fewer eggs. In contrast, there was no difference in the amount of Western Grape leafhopper eggs by variety.

Figure 2. Average number of Virginia creeper leafhopper eggs per gram of leaf in three varieties.

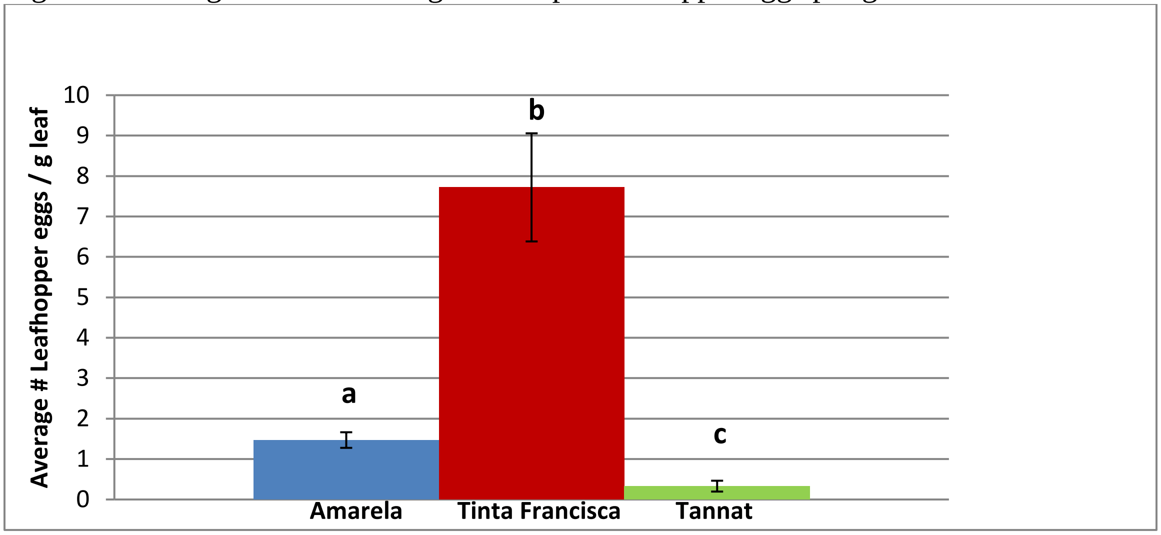


Chart column labeled with a different letter are significantly different at α=0.05 using Tukey's HSD procedure.

Figure 3. Average number of Western grape leafhopper eggs per gram of leaf in three varieties.

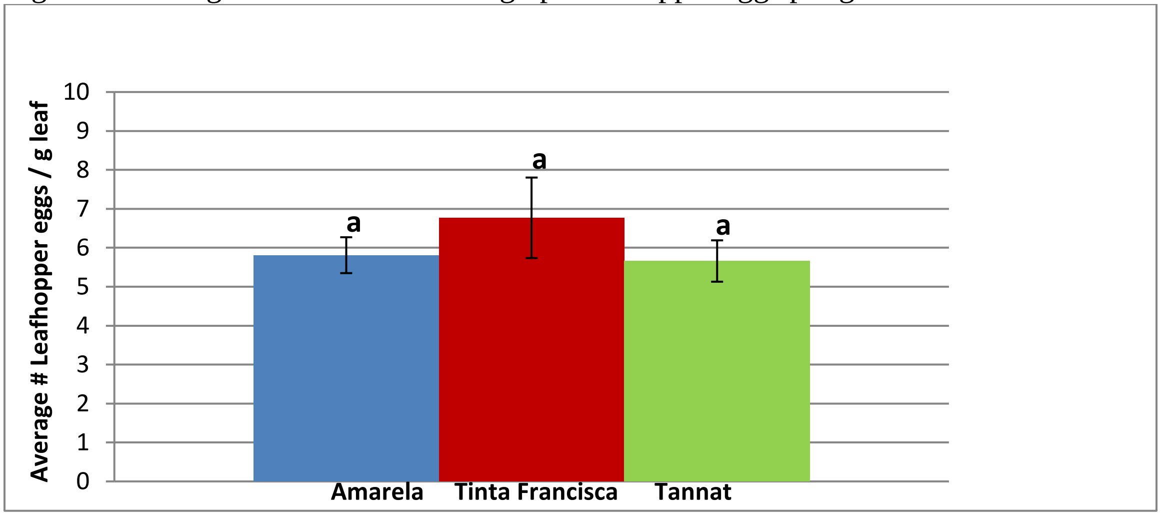


Chart columns labeled with the same letter are not significantly different at α>0.05 using Tukey's HSD procedure.

1b. Determine parasitoid species present in vineyards infested with Virginia creeper and Western grape leafhopper species

Identification of the *Anagrus* species reared from isolated eggs of VCLH and WGLH indicated that in Mendocino County WGLH is being attacked by both *A. daanei* (13%) and *A.*

erythroneurae (87%). This matches with evidence from previous surveys in Napa and Sonoma County, where WGLH was found to be attacked by the same 2 species of *Anagrus*. VCLH is not being parasitized in Mendocino County at all, but *Anagrus* specimens reared from VCLH eggs from Yolo County were all identified as *A. daanei* (Table 2).

Table 2. *Anagrus* species parasitizing Virginia creeper and Western grape leafhopper eggs

	Mendocino	**Napa/Sonoma**	**Yolo**	**Previous Studies**
VCLH	No parasitism	-	*A. daanei*	*A. daanei; A. tretiakovae*
WGLH	*A. daanei; A. erythroneurae*	*A. daanei A. erythroneurae*	-	*A. daanei; A. erythroneurae*

These results indicate interesting differences in the populations of *A. daanei* found in Mendocino and Yolo County. If *A. daanei* is attacking VCLH eggs in Yolo County, why is this same species not attacking them in Mendocino County? Potential hypotheses to explain these results include (1) *A. daanei* in Mendocino and Yolo Counties are actually separate species and (2) *A. daanei* in the two locations are the same species, but represent 2 separate populations and the Mendocino population exhibits a stronger preference for WGLH over VCLH. These questions will be addressed in our 2014 work (see proposal).

2. Identify Anagrus species collected and reared from leafhoppers on host plants found near vineyards

Identification of the *Anagrus* species reared from host plants in the habitats surrounding vineyards revealed that *A. erythroneurae* made use of a variety of hosts and was fairly abundant while *A. daanei* was restricted to just a few hosts and overall rarely encountered outside of vineyards. To account for differences in sampling effort, results for each *Anagrus* species are presented in terms of number of individuals reared per gram of plant material sampled. Results are also broadly categorized by habitat type to indicate those plants found naturally occurring in the North Coast landscape as versus species intentionally cultivated in gardens and hedgerows.

Table 3. Non-crop host-plants utilized by *A. erythroneurae* and *A. daanei* in the North Coast

Habitat	**Common Name**	**Plant Species**	***Anagrus* species**	**Wasps/gram ($x10^{-2}$)**
Natural Habitat	Coyotebrush	*Baccharis pilularis*	A. erythroneurae	3.2 ± 1
	Blackberry	*Rubus* sp.	A. erythroneurae A. daanei	2.0 ± 1 1.1 ± 1
	Wild grape	*Vitis* sp.	A. erythroneurae A. daanei	1.2 ± 1 1.2 ± 1
	Alder	*Alnus* sp.	A. erythroneurae	0.9 ± 0.5
	Coast live oak	*Quercus agrifolia*	A. erythroneurae	0.5 ± 0.5
	California buckeye	*Aesculus californica*	A. erythroneurae	0.4 ± 0.4
	Manzanita	*Archtostaphylos* sp.	A. erythroneurae	0.3 ± 0.3
Gardens and Hedgerows	Catnip	*Nepeta* sp.	A. erythroneurae A. daanei	16.6 ± 10 0.5 ± 0.5
	Mint	*Mentha* sp.	A. erythroneurae	8.6 ± 2
	Sage	*Salvia* sp.	A. erythroneurae	6.4 ± 3
	Ceanothus	*Ceanothus* sp.	A. erythroneurae	4.4 ± 2
	Rose	*Rosa* sp.	A. daanei	0.6 ± 0.6
	Apple	*Malus* sp.	A. erythroneurae	0.5 ± 0.5

While many of the garden/hedgerow species were excellent hosts for overwtinering *Anagrus* (i.e. catnip and mint), these plants are rarely encountered on a large scale in the North Coast and typically are not found near many vineyards. Whereas species such as *B. pilularis* and *Rubus* sp. are much more commonly found in natural habitats near vineyards in this region and are more likely the key determinants of localized *Anagrus* populations.

We found that many non-crop plants consistently yielded *Anagrus* wasps throughout the entire year, including *B. pilularis*, *Mentha* spp., *Nepeta* sp., *Rubus* sp., and *Salvia* sp. This indicates that some portion of the *A. daanei* and *A. erythroneurae* population is maintained outside of vineyards throughout the growing season and these host plants could possibly serve as a source pool for *Anagrus* to recolonize crops following insecticide and fungicide sprays.

Furthermore, it should be noted that some host species are only available for a limited time due to their phenology. For example, *Aesculus californica* produces leaves in the early spring which non-pest leafhoppers feed on and *Anagrus* parasitize their eggs. *A. californica* is not tolerant of drought conditions though and when soil moisture reaches a critical threshold this plant drops all of its leaves and is no longer a suitable host for leafhoppers/*Anagrus*. In the North Coast this leaf drop typically occurs as early as May and as late as September, depending on local soil moisture conditions (Wilson, pers. obs.)

Table 4. *Anagrus* utilization of host plants at different times of the year.

Plant	**Winter** **Dec. – Feb.**	**Spring** **Mar. – Apr.**	**Summer** **May. – Sept.**	**Fall** **Oct. – Nov.**
Manzanita	x			
Ceanothus	x	x		x
Catnip	x	x	x	x
Coyotebrush	x	x	x	x
Mint	X	x	x	x
Blackberry	x	x	x	x
Sage	x	x	x	x
Alder		x	x	x
Coast oak		x		
California buckeye		x		
Wine grape			x	
Wild grape			x	x
Apple				x

Paired with this work to identify *Anagrus* species and their host plants was a similar effort to collect and identify leafhoppers on non-crop plant species in/around vineyards. While D-VAC sampling did reveal small populations of VCLH and WGLH adults residing on non-crop plants surrounding the vineyard, both of these leafhoppers were overwhelming found on cultivated grapes during the growing season (Table 4, Table 5, Figure 4). As we moved into the late fall and the grape vines began to lose their leaves, we found VCLH and WGLH on a wider range of non-crop plants, but again in small populations. In the late fall, a majority of the VCLH and WGLH could be found residing in what remained of the grape vine canopy as well as in leaf letter and detritus on the vineyard floor. In this survey, WGLH was not found on the vineyard floor in Mendocino County vineyards, but this is likely due to their low populations in the vineyard where we sampled. Surveys from Napa/Sonoma and other regions have shown this is where WGLH primarily reside during the winter (Wilson pers. comm., UC IPM 2014).

Table 5. VCLH abundance (±SE) per D-VAC sample in vineyards and non-crop habitats

Habitat	Plant	August	October/November	December
Vineyard and Natural Habitats	Wine Grape	32.3 ± 15.7	586.7 ± 352.8	-
	Wild grape	1.0 ± 1.0	79.5 ± 51.7	-
	Vineyard Floor	-	97.5 ± 80.9	133.47 ± 112.6
	Willow	-	2.8 ± 2	-
	Blackberry	-	0.5 ± 0.3	-
	Alder	-	0.4 ± 0.4	-
	Poplar	-	0.2 ± 0.2	-
Gardens and Hedgerows	Rose	1.3 ± 1.3	6.8 ± 2.9	-
	Mint	-	4.5 ± 3.9	-
	Linden	-	1.0 ± 1.0	-
	Plum	-	0.3 ± 0.3	-
	Catnip	-	0.2 ± 0.2	-

Figure 4. Proportion of VCLH found on wine grape, wild grape and vineyard floor relative to all other non-crop plants sampled (August-December 2013)

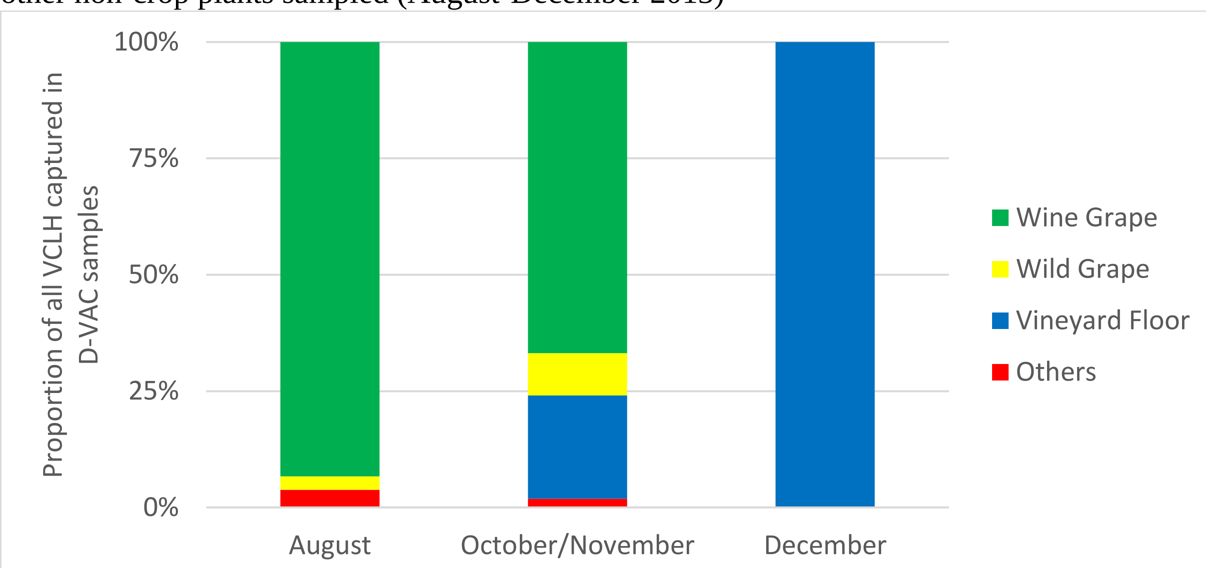


Table 6. WGLH abundance (±SE) per D-VAC sample in vineyards and non-crop habitats

Habitat	Plant	August	October/November	December
Vineyard and Natural Habitats	Wine grape	11 ± 5.5	52.4 ± 27.8	-
	Wild grape	17.2 ± 7.7	10.5 ± 3.9	-
	Vineyard Floor	-	4 ± 1.6	-
	Blackberry		1.7 ± 1.3	0.3 ± 0.3
	Coyotebrush	0.3 ± 0.3	-	-
	Toyon	0.3 ± 0.3	0.7 ± 0.7	-
	Alder	0.3 ± 0.2	0.3 ± 0.3	-
	Oak	-	1 ± 0.6	-
	Bay	-	0.3 ± 0.3	-
	Poplar	-	0.3 ± 0.2	-
	Willow	-	0.3 ± 0.3	-
Garden and Hedgerow	Linden	40 ± 5.5	59.8 ± 12.3	-
	Rose	16 ± 16	9 ± 4.5	-
	Mint	-	5.9 ± 4.2	-
	Virginia creeper	4.3 ± 2.2	3.2 ± 2.4	-
	Citrus	0.3 ± 0.3	1.3 ± 1.3	-
	Sage	-	0.7 ± 0.3	-
	Catnip	-	0.3 ± 0.3	-
	Ceanothus	-	0.3 ± 0.3	-
	Plum	-	0.3 ± 0.3	-

Similar to the display of results from the *Anagrus* sampling, we divided plant samples into 2 categories ("Vineyard and natural habitat" and "Garden/Hedgerow") to differentiate between natural and novel host plants. While a plant like linden (*Tilia* sp.) contained a large population of WGLH, this tree is rarely found in the North Coast landscape and likely has little influence on leafhopper populations in most vineyards. When focusing only on the more common "Vineyard and natural habitat" plant species, it appears that wild grape is a highly preferred non-crop host outside of vineyards for both VCLH and WGLH. Further evidence of this came during our August surveys, when we actually found VCLH eggs and nymphs on wild grape leaves. If VCLH can reproduce on wild grape then it could serve as a source population leading to outbreaks in commercial vineyards. For instance, a small number of VCLH colonizers from wild grape could exploit crop conditions to rapidly re-establish their population following an insecticide spray. Our 2014 proposal includes work to better understand VCLH use of wild grape as refugia and a reproductive site during the season.

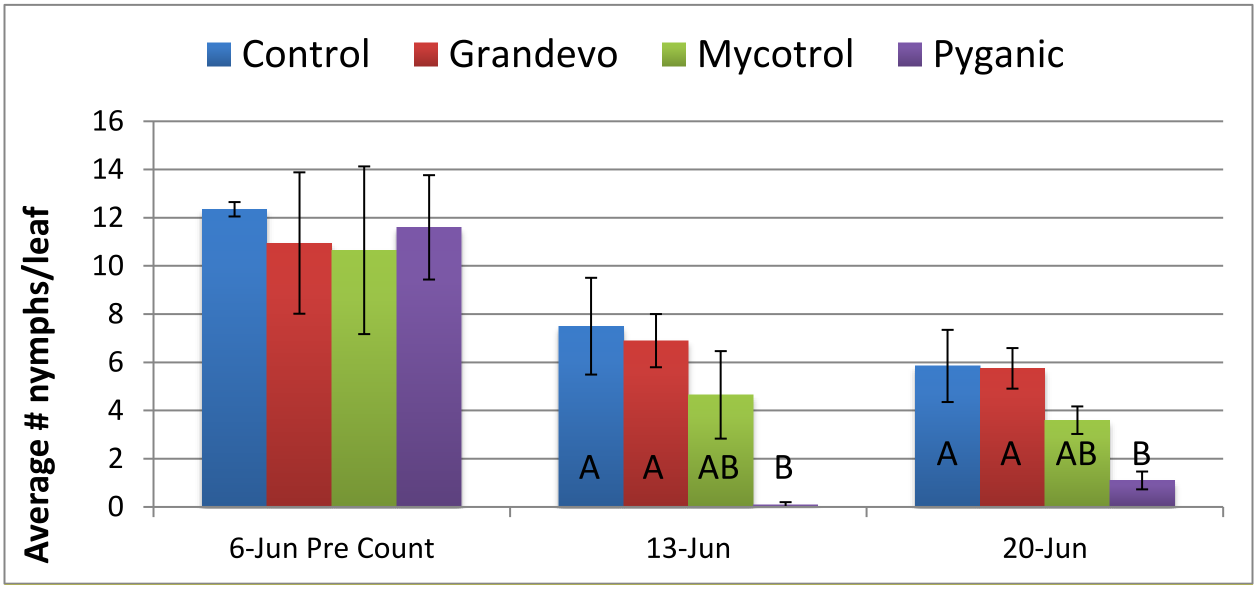
4. Determine the effectiveness of OMRI approved products for VCLH control

In the pre-count on June 6 the number of nymphs per plot (Table 6 and Figure 6) was not significantly different and there was no difference between treatments (p-value 0.9743). After the first insecticide application, the evaluations on June 13 and June 20 treatments were significantly different (p-value 0.0046 and 0.0269, respectively) with Pyganic® having significantly lower population than the control, while Mycotrol® and Grandevo™ were not significantly different from the control. No significant difference between treatments was observed for the evaluation conducted on July 3 (p-value 0.0813) after the second application of Mycotrol® and Grandvo™ of June 27.

Table 7. Average number of leafhoppers nymphs per leaf (± SE) before and after insecticide treatment.

Date	Pyganic®	Mycotrol® O	Grandevo™	Control
June 6 (Pre-count)	11.6 ± 2.2 a	10.7 ± 3.5 a	11.0 ± 2.9 a	12.4 ± 0.3 a
June 13	0.1 ± 0.1 b	4.7 ± 1.8 ab	6.9 ± 1.1 a	7.5 ± 2.0 a
June 20	1.1 ± 0.4 b	3.6 ± 0.6 ab	5.8 ± 0.8 a	5.9 ± 1.5 a
July 3	1.6 ± 0.7 a	1.5 ± 0.5 a	5.1 ± 1.6 a	5.2 ± 1.4 a

Figure 5. Average number of leafhopper nymphs per leaf (±SE) before and after insecticide treatment.



Pyganic® was the only product that significantly reduced the leafhopper nymph population from that of the control for at least 10 days. There is a decrease in the number of nymphs per leaf in all treatments over time. This is due to the development of the canopy and nymphs moving to adjacent leaves, thus increasing the surface area available for the nymph population.

7. Outside Presentations of Research

Oral Presentations:

"The VCLH, A New Pest For Our Region." *Allied Grape Growers Meeting*, Ukiah, CA. March 27, 2013. 80 grape growers from Northern California at Barra of Mendocino Winery. ***Presented by G. McGourty***

"Update on the Biology and Control of the VCLH." *Napa County Farm Bureau Pest Management Meeting*, Napa Valley College. Oct. 29, 2013. ***Presented by G. McGourty***

"Update on Progress and Control of the VCLH." *Fetzer Grower Services IPM Meeting*, Hopland. CA. Nov. 21, 2013. ***Presented by G. McGourty***

"Virginia creeper leafhopper a new pest in the North Coast." *UCCE Sonoma County Grape Day*. Santa Rosa, CA. Feb. 20, 2013. 235 in attendance. ***Presented by Lucia Varela***

"Virignia creeper leafhopper." *Ag. Unlimited 17th Annual Grower Meeting*. Hopland, CA. Feb 26-28, 2013. 335 in attendance. ***Presented by Lucia Varela***

"Virginia creeper leafhopper: New to North Coast Vineyards." *Napa Valley Vineyard Technical Group Pest and Disease Forum*. Yountville, CA. Mar. 6, 2013. 245 in attendance. ***Presented by Lucia Varela.***

"Invasive Pests Update" *North Coast CAPCA Spring Meeting*. Rohnert Park, CA. Apr. 3, 2013. 65 in attendance. ***Presented by Lucia Varela.***

"Virginia creeper control in organic vineyards." *Fetzer/Bonterra Grower Seminar*. Hopland, CA. May 3, 2013. 72 in attendance. ***Presented by Lucia Varela.***

"Virginia creeper leafhopper trial updates." *UCCE Mendocino County VCLH Field Day*. Hopland, CA. July 18, 2013. 26 in attendance. ***Presented by Lucia Varela***.

"Virginia creeper leafhopper display." *Sonoma County Winegrape Commission Sustainable Winegrowing Field Day*. Forestville, CA. Aug. 8, 2013. 98 in attendance. ***Presented by Lucia Varela.***

Publications:

Varela, L. G., Daane, K. M., Phillips, P. A., Bettiga, L. J., and **Triapitsyn, S. V.** 2013. Virginia creeper leafhopper, pp 273-276. In Bettiga, L. [eds.]. UC IPM Grape Pest Management Manual, 3rd Edition, University of California, Agriculture and Natural Resources Publication 3343.

Daane, K. M., Rosenheim, J. A., Smith, R. J., and Coviello, R. 2013. Grape leafhopper, pp 202-219. In Bettiga, L. [eds.]. UC IPM Grape Pest Management Manual, 3rd Edition, University of California, Agriculture and Natural Resources Publication 3343.

Daane, K. M., Coviello, R., Bentley, W. J., Rosenheim, J. A. 2013. Vareigated leafhopper, pp 222-234. In Bettiga, L. [eds.]. UC IPM Grape Pest Management Manual, 3rd Edition, University of California, Agriculture and Natural Resources Publication 3343.

Hogg, B. N., and **Daane, K. M.** 2013. Contrasting landscape effects on species diversity and invasion success within a predator community. Diversity and Distributions Diversity 19(3): 281–293, doi: 10.1111/j.1472-4642.2012.00935.x

Hogg, B. N., and **Daane, K. M.** 2014. The roles of top and intermediate predators in herbivore suppression: contrasting results from the field and laboratory. Ecological Entomology (in press)

Strategy for Communicating Results to End-Users:
As this work progresses, we will continue to present relevant findings and updates on VCLH management to a variety of grower and industry stakeholders. Venues would likely include grower and professional society meetings (i.e. Allied Grape Growers, County Farm Bureau, Association of Applied Insect Ecologists etc.). Research results will also be published in both scientific and industry journals (i.e. Environmental Entomology, Practical Vineyard and Winery, UC ANR publications etc.). Information will also be made available through county extension websites.

8. Research Success Statements

We determined parasitism levels of both WGLH and VCLH in Mendocino County vineyards. Parasitism of the VCLH was practically non-existent in this region and may partially explain why growers have recently been experiencing outbreaks. We also evaluated VCLH and WGLH egg deposition on grape leaves with various levels of trichome density. VCLH clearly prefers grape varietals with more glabrous (smooth) leaves while WGLH appears to have no preference.

We completed the identification of over 2200 specimens of *Anagrus* that were reared from non-crop habitats in/around North Coast vineyards over the past 2 years. Knowing the host-plant associations for these parasitoids is critical for our understanding of vineyard leafhopper/*Anagrus* population dynamics. A lack of suitable overwintering habitat for *A. daanei* could help explain recent outbreaks of VCLH in Mendocino County and elsewhere. We now know that *A. daanei* is fairly limited by its small range of overwintering host plants. Knowledge of novel *Anagrus* overwintering habitat ultimately provides new information for growers interested in re-establishing overwintering habitat for *Anagrus* populations in order to enhance biological control of VCLH and/or WGLH.

We also identified dozens of *Anagrus* specimens that were reared from WGLH and VCLH eggs on cultivated grape vines. Knowing the identity of the parasitoids attacking (or not attacking) VCLH is an initial step towards development of a sustainbale management program for growers. We were intrigued to find that *A. daanei* was not attacking VCLH in Mendocino County, when this same species of parasitoid was found attacking VCLH in Yolo County. These may be simply 2 different populations of *A. daanei* or actually 2 separate species. Regardless, their does exist an opportunity to possibly transfer some of the *A. daanei* from Yolo County into Mendocino County in order to augment biological control of VCLH. Further evaluation of these 2 populations is necessary before any such action takes place (see proposal).

Monthly D-VAC sampling for VCLH and WGLH from habitats surrounding vineyards has given us an idea of the non-crop plant species utilized by these pests as well as the timing of their use. This information will help us plan future experiments to evaluate VCLH use of wild grapes as refugia and reproductive sites. Ultimately growers will benefit from new information about plant species near their vineyard that could potentially be serving as habitat for VCLH. Removal of such plant species could possibly reduce VCLH populations over the growing season.

Results from the spray trials provides new information on the effectiveness of commonly used OMRI approved products to control VCLH as well as the timing and frequency of applications. Work in 2014 will focus on timing and frequency of non-OMRI products (see proposal). If this pest is indeed a vector of Red Blotch, then a spray program that is adapted to the unique biology of VCLH must be developed immediately.

9. Funds Status

All funds have been appropriately spent and will be closed by the end of the granting period. Salary positions include partial funding for a Student Assistant (Houston Wilson) and Laboratory Assistant. Houston was responsible for collecting *Anagrus* and leafhopper specimens from habitats around the vineyards as well as isolation and rearing of *Anagrus* specimens for identification. Serguei Triapitsyn identified the *Anagrus* specimens to species and coordinated the molecular work. Lucia Varela conducted the spray trial. Glenn McGourty and the Mendocino County extension office assisted the grant by providing their lab tech Ryan Keiffer to help Lucia and Houston with field work. Kent Daane provided guidance for experimental design and lab space at the UC Berkeley greenhouse. Travel costs include trips to field sites in Napa, Sonoma and Mendocino County. Supplies and expensies costs were primarily used for mounting and identification of the *Anagrus* specimens and field supplies to collect the *Anagrus*/leafhopper samples.

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