ABSTRACTS FOR

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1. IMPROVED MANAGEMENT OF CUCUMBER BEETLES IN CALIFORNIA MELONS

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In recent years cucumber beetles (Chrysomelidae) have become increasingly problematic as pests of melons grown in the Sacramento and San Joaquin Valleys of California. The primary source of damage comes from feeding on the rind of the developing fruit by adults, and occasionally by larvae, which creates corky lesions and renders the fruit unmarketable, especially for export. Larval feeding on the roots may also be contributing. There are two species of cucumber beetles that are pests of California melons: Western spotted cucumber beetle (*Diabrotica undecimpunctata undecimpunctata* Mannerheim) and Western striped cucumber beetle (*Acalymma trivittatum* Mannerheim). Monitoring of both species in Sutter and Colusa Counties began mid-season in July 2007 to investigate biology, distribution, and population dynamics but has not yet produced conclusive results. A study comparing the effects of different insecticide treatments with and without a cucurbitacin-based feeding stimulant called Cidetrak® was initiated in the summer of 2007. Cidetrak did appear to reduce beetle numbers when combined with either Spinosad or low doses of Sevin XLR Plus. None of the treatments however, reduced cosmetic damage sustained to the fruit. The limited plot size may have compromised the integrity of the treatments. Future studies will utilize field cages or larger plots in order to prevent movement between treatment plots.

2. PATTERNS OF INSECT CAUSED CUTTING FAILURE WITHIN AN IRRIGATED PERENNIAL CROP

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The inland Pacific Northwest has an ideal climate in which hybrid poplars can be grown as an irrigated perennial crop. Harvest generally occurs during winter, when most root pests are dormant, and by spring the growers replant the recently harvested areas. When these root pests

break diapause, their food source has been removed and they actively seek a new food source, potentially causing fatal root damage to the newly planted poplar cuttings. Cutting mortality within a planting unit was recorded following each replant. Using Spatial Analysis and Decision Assistance (SADA) we discerned patterns of insect caused cutting failure within individual units. We found that patterns of cutting failure were consistent for a given pest across all units. These findings suggest that insect caused cutting failures occur in discernable patterns linked to specific pests. These patterns indicate that both sessile and mobile pests attack hybrid poplar cuttings. Our illustration of insect caused cutting failure through SADA allows the growers to identify problematic areas within the farms and address pest problems within individual units based on failure patterns.

3. PREDICTING PARASITOID POPULATION DYNAMICS RESULTING FROM NOVEL INTERACTIONS OF CLIMATE CHANGE AND SELENIUM POLLUTION

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Our research has investigated the individual and joint effects of increased temperatures and the anthropogenic pollutant selenium (Se) on the life history on the parasitoid *Cotesia marginiventris* (Cresson) attacking the beet armyworm, *Spodoptera exigua* (Hubner). Previous research has indicated that parasitoids can be affected detrimentally by environmental pollutants, and that changes in insect-plant interactions due to global climate change are likely to have consequences for higher trophic levels. However, information regarding the effects of these factors on parasitoids is relatively sparse. Our specific objective was to determine in a factorial experiment how three temperatures (constant 28.6°C, constant 33°C and a fluctuating temperature between 28.6 and 33°C) and three concentrations of seleno-DL-methionine (0.00, 10.59, and 21.21 μg/g) affected this parasitoid's survival, development and fecundity. *Cotesia marginiventris* larvae exhibited a significant temperature by selenium interaction on development time. There were significant declines due to increased temperature, but not selenium, on adult *C. marginiventris* female lifespan and fecundity. Mean generation times and the intrinsic rate of increase (r) further show that both of these life table statistics declined under conditions of increasing levels of selenium and temperature. These data will be used to increase the potential for the success of biological control programs.

4. IS THERE INTERFERENCE AMONG MEALYBUG SEX PHEROMONES USED IN PHEROMONE-BAITED TRAPS FOR MONITORING MEALYBUGS?

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Mealybugs are key pests in numerous crop and nursery settings. Conventional mealybug monitoring practices typically consist of visual sampling of plant material. However, mealybugs are cryptic, and many are probably missed while sampling. The presence of mealybugs or their population density is difficult to determine. A potential alternative monitoring technique would use sticky traps baited with mealybug sex pheromones to attract adult males. Three mealybug species are key pests in nurseries: citrus mealybug (*Planococcus citri*), obscure mealybug (*Pseudococcus vibruni*), and longtailed mealybug (*Pseudococcus longispinus*), and their sex pheromones have now been identified. With work reported here, our goal was to determine whether the pheromones of all three species could be combined into one lure, or whether the pheromones might interfere with each other. In a previous study, results suggested that combining three pheromones into a single trap slightly reduced the total catch of male mealybugs compared to traps that contained a single pheromone. Results are presented here assessing catches in traps containing one pheromone compared with traps containing two and three pheromones in order to determine which combination might cause interference. Additionally, the antennal responses of male mealybugs exposed to other species' sex pheromones were assessed using gas chromatography – electroantennography (GC-EAG).

5. SHUTTING DOWN THE COOLING SYSTEM: WATER STRESS, LEAF TEMPERATURE AND SPIDER MITE OUTBREAKS IN VINEYARDS

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Every year grape growers in California spray 250,000 acres with pesticides to control outbreaks of spider mites at a cost of 20 million dollars. While many ecological studies link outbreaks of spider mites to plant water stress, very little is known about the mechanisms facilitating high population growth. We tested the hypothesis that higher leaf temperatures, induced by water stress, is one of the mechanisms encouraging population outbreaks of spider mites. We measured leaf temperature, water stress and mite densities through the season in eight California vineyards in 2006 and 2007. Our results link Pacific spider mite (*Tetranychus pacificus* – PSM) outbreaks to water stress and the frequency of high temperatures on south-facing leaves. We found a positive relationship between water stress and leaf temperature, with water stressed plants having warmer leaves with higher PSM populations. However, we found no relationship between high leaf temperatures and Willamette spider mite (*Eotetranychus willamettei*), indicating that different species respond to water stress in different ways. Our study illustrates the potential of cultural practices, such as deficit irrigation, to cause PSM outbreaks, as well as the possibility of increasing PSM outbreaks in the future as climate change reduces water availability during summer months.

6. SPIDER DIVERSITY AND HERBIVORE SUPPRESSION IN CALIFORNIA WINE VINEYARDS

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Changes in predator diversity can have differing impacts on herbivore suppression, depending on how predators interact. In a manipulative field study, cages in California vineyards were stocked with different combinations of spider species and resulting effects on the grape leafhopper *Erythroneura elegantula* Osborn (Cicadellidae) were assessed. Species identity appeared to be the most important factor in determining which spider combinations were effective in suppressing leafhoppers: all treatments that contained the wandering spider *Cheiracanthium mildei* L. Koch (Miturgidae) had significantly lower leafhopper densities than other treatments. Despite its predatory impacts on leafhoppers, *C. mildei* also appeared to reduce numbers of another wandering spider, *Anyphaena pacifica* Banks (Anyphaenidae). *C. mildei* may therefore play a dual role in vineyards, acting as both an intraguild predator and an important natural enemy of herbivorous pests.

7. PUPATION SITES OF *SCIRTOTHRIPS CITRI* AND INFECTIVITY OF *BEAUVERIA BASSIANA* TO *S. CITRI* IN LABORATORY STUDIES

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Citrus thrips, *Scirtothrips citri* (Moulton), is a plant-feeding pest most widely recognized for damage caused to citrus and mango. Recently, it has broadened its known host range to become a significant pest of blueberries grown in California's San Joaquin Valley. Knowledge of this insect's life cycle coupled with identifying pupation sites on blueberry bushes has suggested the possibility of using *Beauveria bassiana* (Balsamo) to aid in field control of pupae in the upper layers of soil as an alternative to traditional pesticides. Laboratory bioassays have been conducted to determine sites of pupal refuge and the percent infection after exposure to several fungal isolates. The results of pupation site locations and these infection trials will be discussed as well as a comparison of the efficacy of the isolates.

8. INTRAFIELD SPATIAL DISTRIBUTION AND PRECISION SAMPLING OF THRIPS IN TIMOTHY.

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Timothy (*Phleum pratense* L.) is a cool-season forage grown in several Western states. In California, the major thrips species found in timothy is *Anaphothrips obscurus* Müller, but *Frankliniella occidentalis* Pergrande co-occurs. We analyzed sampling method comparison data in 2006 and 2007 timothy and found that direct observation was the most absolute sampling method tested. The beat cup method is commonly used by scouts in timothy, because of perceived accuracy, precision and time savings. We compared direct observation of thrips and the beat cup method across 16 grower fields in both 2006 and 2007. Direct observation was assumed to be the most accurate method; the precision of each method was compared in each year by using the coefficient of variation for each field. We found that the precision of the beat cup method was not significantly different than that of direct observations. Also, we used Taylor's power law on direct observation counts for each year to describe the spatial distribution of thrips in timothy fields. We obtained an equation describing the populations as aggregated within fields. However, this description may be biased, due to low population means and spatially dependent sample data collection.

9. INVESTIGATING HOST PLANT ACCEPTANCE IN ESTABLISHMENT SUCCESS OF *DIORHABDA ELONGATA* FOR BIOLOGICAL CONTROL OF SALTCEDARS

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Releases of *Diorhabda elongata* (Coleoptera: Chrysomelidae) for biological control of *Tamarix* spp. (Caryophyllales: Tamaricaceae) have had varied success at sites across the western United States. Numerous causes have been speculated on, including the possibility that host preferences and adult dispersal were hindering establishment at some sites. I will present data suggesting that an increase in host plant acceptance of *Tamarix parviflora* may have played a role in delayed but successful establishment of the beetles at Northern California release sites. At these sites *Tamarix parviflora* is dominant, and in the past the beetles have shown low preference for this species compared to other abundant invasives in the genus. The investigation highlights the process of host range expansion in successful biological control, in addition to its more traditional role in undesired non-target effects.

10. PREDICTING HYPOSOTER EXIGUAE PRESENCE AND BIOCONTROL ACTIVITY IN VEGETABLE FIELDS: FARM-SCALE VERSUS LANDSCAPE-SCALE INFLUENCES

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Conservation biological control of agricultural pests can be elusive in intensively farmed, annual crop systems. In highly disturbed systems, extra-farm vegetation may be critical habitat for maintaining local natural enemy populations and conserving the biological control services they provide. Alternatively, in-field practices that minimize disruption of the biotic community may be more important than more distant resources. We measured the relative strengths of association between parasitoid abundance, on-farm management practices and extra-farm vegetation classes at 30 commercial farm sites in California's Central Coast region. The ichneumonid wasp *Hyposoter exiguae*, a common parasitoid of lepidopteran pests, was sampled using Malaise traps in May, July, and September in 2004, 2005, and 2006. Percent parasitism of sentinel larvae was measured in May, July, and September 2007. Farm-scale factors included in the analysis were tillage regime, crop diversity, and pesticide use. Landscape-scale vegetation was characterized by aerial photo interpretation with GPS field-verification and quantified as percentage area at two scales (0.5km and 1.5km radii from farm centers). Research landscapes ranged from primarily agricultural to complex vegetation-landuse mosaics, and on-farm practices ranged from highly-mechanized monoculture production to hand-tilled mixed vegetable production. Opportunities and constraints for enhancing biological control in agricultural landscapes will be addressed.

11. CONSERVATION OF INSECT DIVERSITY IN AN ALPINE ECOSYSTEM

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Few studies have examined the relationship between space and genetic variation in a diverse set of insects across the same geographic area. However, it is generally appreciated that populations with high levels of genetic diversity are important targets for conservation. Genetically diverse populations harbor the raw material for adaptation and are more resilient to the effects of inbreeding. I examine the spatial patterning of genetic diversity in multiple insect species inhabiting alpine habitats in the California Sierra Nevada. These results also document the history of high elevation habitats during periods of extreme environmental change, including several glacial and interglacial cycles. Finally, to highlight priority areas for management and conservation under climate change, I develop species distribution models for several of these insects. Using annual climate data, I examine how climate records over the last century suggest that declines in alpine species are likely to have occurred in the northern Sierra Nevada.

12. THE INFLUENCE OF RELATIVE ABUNDANCE AND SPECIES IDENTITY ON THE EFFECTIVENESS OF GENERALIST PREDATORS IN BIOCONTROL

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Within cropping systems natural enemies typically vary in relative abundance, such that one or a few species are highly abundant while most are relatively scarce. The role of relative abundance in the mortality imposed by natural enemies on pest species has not been tested in managed systems, nor has the role of taxonomic identity of natural enemies on the relation between relative abundance and mortality imposed on pests. We investigated the influence of relative abundance and taxonomic identity on the mortality imposed by three generalist arthropod predators of the imported cabbageworm, *Pieris rapae*, on collards (*Brassica oleracea* var. *acephala*). We altered the relative abundance of the generalist predators in experimental mesocosms and determined the mortality of first instar cabbageworms. In addition to the mesocosm experiments, we determined the influence of relative abundance and taxonomic identity on predator-predator interactions. The influence of relative abundance on the mortality of cabbageworm larvae was dependent on the taxonomic identity of the highly abundant predator. Further, the level of mortality imposed by highly abundant predators was in some cases influenced by the occurrence of intraguild predation. Our results suggest that preservation of highly abundant predators in managed systems via conservation biological control strategies may not always be the most effective strategy in controlling pests, but rather that the benefit of such strategies may depend on both abundance and identity of natural enemies.

13. HEAT INDUCES DIPLOID MALE PRODUCTION IN THE *WOLBACHIA*-INFECTED CHALCIDOID WASP, *TRICHOGRAMMA KAYKAI*

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Sex determination in the haplodiploid order, Hymenoptera, has been studied extensively but is still not well understood. While cytoplasmic and environmental factors have been shown to occasionally influence sex determination in the Hymenoptera, the genetic mechanism, Complementary Sex Determination (CSD), is the only well known mechanism of sex determination in this order. However, CSD does not explain sex determination in members of the superfamily, Chalcidoidea. In the chalcidoids, temperature and the cytoplasmic reproductive parasite, *Wolbachia,* have often been demonstrated to significantly affect sex determination. This study uses heat treatment and *Wolbachia* infection to manipulate the sex determining process in the chalcidoid wasp, *Trichogramma,* inducing the production of diploid males. This is the first documented case of diploid males occurring in the chalcidoids in the absence of mutation. Such a finding may provide valuable insight into the mechanisms used by *Wolbachia* to manipulate host

reproduction and may have important implications for evaluating sex determination in *Trichogramma* and other chalcidoids.

14. ODORANT BINDING PROTEINS (OBPS) FROM MALARIA MOSQUITO *ANOPHELES FUNESTUS*

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The principal human malaria vector species in Sub-Saharan Africa are *Anopheles gambiae* sensu stricto and *Anopheles funestus* sensu stricto. Extensive research has been conducted on the behavior, ecology and genomics of *An. gambiae* compared to *An. funestus* due to the hard colonization of the latter species in the laboratory. However, their degrees of specialization on humans by being highly anthropophilc and endophilic makes them almost equally important malaria vectors. Olfaction is essential in guiding mosquito behaviors. Odorant binding proteins (OBPs) are highly accumulated in sensillar lymph and involved in the transport of odorants to the receptors. Our goal is to clone OBPs from *An. funestus* and compare them with OBPs from *An. gambiae*. This study will help us understand the similarities and differences of olfaction in these two important malaria vectors on the molecular basis.

15. EFFECTS OF VEGETATION ON THE EFFICACY OF LARVAL MOSQUITO (DIPTERA: CULICIDAE) CONTROL BY A NATIVE LARVIVOROUS FISH

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Created wetlands are often planted with vegetation, creating microhabitats suitable for the production of large numbers of mosquitoes. Previous studies have found that wider bands of vegetation reduce the efficacy of *Gambusia affinis* to control larval mosquito populations. This study examines the effects of vegetation patch size on two other predators of larval mosquitoes, backswimmers (Hemiptera: Notonectidae) and arroyo chubs (*Gila orcutti*). The arroyo chub was chosen since it is native to southern California, has a capacity to control larval mosquitoes, and is a species of special concern due to urbanization and to competition with introduced fish. In autumn 2006, twelve ponds at the UC Riverside Agricultural Experiment Station received additions of the bulrush *Schoenoplectus californicus* in one of two arrangements such that twelve 0.1 m^2 (or single plant) plots, four 0.4 m^2 (or four plant) plots, and two 0.9 m^2 (or nine plant) plots were present. All twelve wetlands received additions of *Notonecta*. Six wetlands received additions of 30 g of *G. orcutti*. Samples taken through April 2007 show those wetlands with fish have significantly fewer mosquitoes than wetlands without fish. While there was not a significant fish × vegetation plot size interaction, mosquito abundance in the 0.4 m^2 bulrush plots was consistently greater than in the 0.1 m^2 plots, though mosquito abundance in these two smaller vegetation plots did not differ significantly from the largest plots. Samples were taken through

autumn 2007 and are being processed to assess whether the arroyo chub can provide season-long control of larval mosquitoes.

16. THE EFFECTIVENESS OF PYRIPROXYFEN ON OBLIQUEBANDED LEAFROLLER, *CHORISTONEURA ROSACEANA* (LEPIDOPTERA: TORTRICIDAE)

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The obliquebanded leafroller (OBLR), *Choristoneura rosaceana* (Harris), is one of the most destructive pests of tree fruits in Washington. The development of insecticide resistance in OBLR has led us to explore new management strategies. The use of very low doses of insecticides that have strong sublethal effects represents an environmentally-friendly option to improve existing integrated pest management strategies. We tested the insect growth regulator pyriproxyfen (Esteem® 0.86EC, Valent Incorporation U.S.A.) to determine its lethal and sublethal effects on OBLR. A leaf-disk bioassay was used to test seven doses of pyriproxyfen ranging from 0.0 to 3.0 µg per final instar OBLR. Male and female larvae were assessed separately for mortality as well as other parameters of growth and development. We found that response to pyriproxyfen was dose-dependent: only 5-6% of the larvae treated with the highest dose emerged as morphologically normal adults, compared to 86% emergence in the controls. Adult emergence was significantly delayed at doses higher than 0.1 µg per larva. The weights of OBLR pupae and adults were significantly increased whereas fecundity and fertility were significantly reduced at a sublethal dose of 0.03 µg per larva. We conclude that both lethal and sublethal effects contribute to the observed reductions of OBLR densities in tree fruit orchards treated with pyriproxyfen.

17. DIVERSIFICATION ON ISLANDS: MICROSATELLITES SHED INSIGHT INTO A RADIATING LINEAGE OF HAWAIIAN PLANTHOPPERS (*NESOSYDNE CHAMBERSI*: HEMIPTERA: DELPHACIDAE)

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Islands have served as laboratories for evolutionary studies because of their tendency to produce rapid diversification within colonist lineages. To investigate intraspecific diversification within an island lineage of host-specialized insects, we analyzed populations of the endemic Hawaiian planthopper *Nesosydne chambersi* (Delphacidae: Hemiptera) at 15 microsatellite loci. This Big Island species is a relatively widespread member of a large radiation. We present an analysis of planthopper genotype data here, including diversification among planthopper populations and the influence of gene flow.

18. SYSTEMATICS, BIOGEOGRAPHY AND CONSERVATION OF THE PHEIDOLE ROOSEVELTI-GROUP (HYMENOPTERA: FORMICIDAE) IN FIJI

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This taxonomic revision treats the members of the *Pheidole* (*Electropheidole*) *roosevelti*-group. The group is remarkable in the extreme modification of their propodeal spines, mesonotal shapes and head shapes. Seven species, all endemic to the Fiji Islands, are recognized: *P. bula* sp. n., *P. colaensis* Mann 1921, *P. furcata* sp. n., *P. pegasus* sp. n., *P. roosevelti* Mann 1921, *P. simplispinosa* sp. n., *P. uncagena* sp. n. Descriptions and diagnostic keys are provided for the minor, major and queen castes. All species are illustrated with digital images, and a map illustrates their geographic distributions across the Fijian archipelago. The group is compared to Pacific congeners with special attention given to species of the subgenus *Pheidole* (*Pheidolacanthinus*) F. Smith. A molecular phylogeny based on mitochondrial and nuclear genes is used to test hypotheses of relationship based on morphology, in addition to biogeographical patterns within Fiji and the Western Pacific.

19. SYSTEMATICS AND BIOGEOGRAPHY OF *CALLOBIUS* (ARANEAE, AMAUROBIIDAE), A SPIDER GENUS DIVERSE IN THE CALIFORNIA FLORISTIC PROVINCE.

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Callobius is a genus comprised of 30 species of hackle-mesh weaving spiders in the family Amaurobiidae. 27 species are North American, 20 of which occur in and 14 of which are endemic to the California Floristic Province. Several other species are endemic to the northern Great Basin in Eastern Oregon, eastern Washington, and Idaho. Although they are very common throughout Western North America, especially in conifer forests, they are infrequently seen because of their cryptic habits. Phylogenetic analysis of 800 base pairs of CO1 and 375 base pairs of Histone 3 provides very little resolution, and shows many currently recognized taxa to be paraphyletic. Moreover, the widespread species *C. severus*, found in coastal mountains from San Diego to British Columbia, shows surprisingly little structure, even in the CO1 data. It is not clear whether the distributions of *Callobius* species carry biogeographic information with respect to the California Floristic Province, however they may be an example of rapid diversification following dispersal events.

20. SEED PREFERENCES OF THE HARVESTER ANT *POGONOMYRMEX RUGOSUS* IN COASTAL SAGE SCRUB

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Coastal sage scrub (CSS) habitat in southern California is disappearing due in part to invasions of exotic annual plants. These exotic annuals interact with seed predators, such as harvester ants, already present in CSS. While we know that ant preferences for harvesting different seeds can determine relative abundances of plants, it is unknown whether harvester ants help or hinder plant invasions in CSS. I investigate the seed preferences of *Pogonomyrmex rugosus*, a very active harvester ant native to CSS, and quantify the relative amounts of native seeds it collects. Native plant species examined include *Artemisia californica*, *Encelia farinosa*, *Eriogonum fasciculatum*, and *Salvia mellifera*. This work is the first part of a larger project on harvester ant interactions with native versus exotic seeds in CSS. Understanding the dynamics of seed removal by harvester ants may have significant implications for the management of exotic annual plants in this unique habitat.

21. CAN POLLEN-FORAGING BUMBLEBEES RECOGNIZE WHICH ROSE FLOWERS ARE MORE REWARDING?

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The flowers of the rose *Rosa rugosa* are nectarless, produce pollen with a scent chemically distinct from the petals, and are pollinated by pollen-collecting bumblebees. We investigated whether bumblebees of *Bombus terrestris* discriminate between flowers containing different amounts of pollen and if so, whether they rely on pollen odor. We conducted three different field experiments: in each, free flying bees were offered a choice of eight flowers, four pollen-rich and four pollen-poor; in one experiment, a main compound in the pollen odor, eugenol, was added to pollen-poor flowers to see if it would make them as attractive as pollen-rich ones. Bee responses to each flower were recorded for 20 fifteen-minute trials. In all experiments, bees discriminated between the two flower types, landing and collecting pollen more on the pollen-rich flowers; however, this was clearly significant only in the first (mid-morning) experiment. Furthermore, the higher visitation to pollen-rich flowers in the experiment with added eugenol suggests that other and/or additional pollen scent compounds may be needed to imitate pollen presence or that bees use cues other than pollen odor in flower selection; use of scent marks left on flowers appears unlikely. Overall, the findings show that bees can recognize reward-rich flowers, which increases their foraging efficiency.

22. ROLE OF VISION AND OLFACTION IN HOST FLOWER RECOGNITION BY THE BEE CHELOSTOMA RAPUNCULI

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Chelostoma rapunculi (Megachilidae) is a European solitary bee that is oligolectic, collecting pollen exclusively from bellflowers (genus *Campanula,* Campanulaceae). In past years, behavioral experiments were conducted to determine how vision and olfaction modulate the bees' recognition of the main local host flower, *Campanula trachelium*; the findings, however, have been inconclusive. In 2007, a series of four new experiments were done to more accurately isolate these two sensory modes, where fresh flowers were placed under hand-crafted glass vials with and without holes. During each 16 minute test, newly emerged bees were given a choice of four flower species; landing and feeding responses as well as amount of time spent near each sample were recorded. When offered only odors (using glass vials with holes, covered with color mesh), bees showed no preference among flowers. When offered only visual cues (solid glass vials) or both visual and olfactory (glass vials with holes), bees displayed different, narrower flower preferences that included *Campanula*. Only when bees were offered unobstructed visual and odor cues (uncovered flowers) did they clearly prefer *Campanula*. This suggests that the ability to perceive changing stimuli upon close approach to flowers together with a synergism between vision and odor are crucial to the bee's recognition of *Campanula*. These findings emphasize the importance of stimulus integration in flower-selection by bees.

23. SELECTION OF BODY SIZE IN FORAGING BEES

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Previous research has demonstrated a link between brain development and foraging experience in the solitary bee *Osmia lignaria*. However, physical features of the bee might also be related to foraging experience. To determine if physically larger individuals are naturally selected as better foragers, a morphometric comparison between experienced and inexperienced female bees was conducted. Two solitary bee species were studied: *O. lignaria* and *Chelostoma rapunculi* (both Megachilidae) were selected. Each individual was measured in terms of head size (width at eyes), head weight and body weight. Bees were also collected at two distinct times in their seasonal activity: shortly after they emerged from their nest cell, and after three weeks of foraging experience. Surprisingly in *O. lignaria*, the experienced were significantly smaller than inexperienced bees in all three measurements. These data will be discussed and compared with those from *C. rapunculi.*

24. *COCCOBIUS* AND THE PUSTULATE PLEURON: PLACING THE UNPLACABLE

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The genus *Coccobius* (Aphelinidae: Hymenoptera) contains 80 described species of small to minute parasitoids of primarily armored scale insects (Diaspididae). They are one of the few wasp groups exhibiting heteronomous development, where females develop as primary endoparasitoids of their scale hosts and males develop as hyperparasitoids, sometimes on conspecific females. They have been used in several biological control projects, with perhaps their most spectacular success occurring against arrowhead scale in Japanese citrus orchards. Though *Coccobius* is clearly monophyletic, its position within Chalcidoidea is uncertain. Currently, it is included within the aphelinid subfamily Coccophaginae, which also includes the more familiar genera *Encarsia* and *Coccophagus*. We conducted a comparative morphological study of the genus, as well as an analysis of 18S and 28S rDNA genes in an effort to study potential sister-group relationships between *Coccobius* and other chalcidoid groups. Our data suggest that *Coccobius* is most likely not a member of the Coccophaginae. Firm conclusions regarding the sister group of *Coccobius* await a more detailed understanding of relationships within Chalcidoidea.

25. SHARED PARASITISM AMONGST TWO LEAFMINER SPECIES: A QUANTITATIVE FOOD WEB APPROACH

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Apparent competition (defined as a negative effect of one species on the population growth rate or abundance of another species, mediated through the action of shared natural enemies), has been shown to be important in structuring insect communities. While competition has been documented between species at all trophic levels (plant, herbivore, and natural enemies), indirect pathways for competition through natural enemies have rarely been quantified in field studies to date. The sunflower (*Liriomyza helianthi*) and blotch leafminer (*Calycomyza platyptera*) along with their community of hymenopteran parasitoids provide a model system for testing the relative strengths of direct and apparent competition in the field. Seven species of parasitoids were reared from the two leafminer species. To inform our field experiment design we developed and analyzed quantitative food webs for ten sites in the Californian central valley and found the webs were able to provide detailed, quantitative information about community structure. Our quantitative food webs show the most common parasitoid genera, *Diglyphus* and *Neochryocharis*, are shared by both leafminer species across a gradient of *L. helianthi*, *C. platyptera* and host plant densities. This project demonstrates the power that quantitative webs have for developing hypotheses to test in the field.

26. *POTATO VIRUS Y* (PVY) (POTYVIRIDAE: *POTYVIRUS*) STRAIN REACTIONS IN HAIRY NIGHTSHADE AND POTATO UPON APHID INOCULATION WITH *MYZUS PERSICAE* (SULZER)

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PVY has several strains associated with necrotic ring spots in potato tubers that are known to cause extensive yield and quality losses. Recent surveys indicate an increased proportion of necrotic strains (NTN and N:O) in North America but the reason for this increase is unknown. PVY is transmitted in a non-persistent manner by aphids with the green peach aphid, *Myzus persicae* (Aphidae: Hemiptera) being the most efficient vector. Hairy nightshade, *Solanum sarrachoides* (Sendtner), an abundantly occurring weed in the Pacific Northwest serve as host for PVY and aphids. Presently no information is available on aphid transmission rates of PVY necrotic strains and their reaction on hairy nightshade. PVY (N:O, NTN and O) were inoculated to hairy nightshade and potato plants individually using *M. persicae*. Higher percentage of infection was observed with necrotic strains (NTN and N:O) than with PVY^{O} in both hairy nightshade and potato. Titer levels were positively correlated with percentage of infection. Necrotic strains reached higher titers in both hairy nightshade and potato than the O strain. These results may explain the reason for the increase in PVY necrotic strains in recent years.

28. THE GENETIC AND CHEMICAL BASIS OF ALTERED SOCIAL STRUCTURE IN A WIDESPREAD INVASIVE ANT

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Invasive species are an acute and increasingly serious threat to agriculture, economies, and ecosystems worldwide. However, despite the breadth and severity of problems they cause, the mechanisms by which introduced populations become successful invasive species often remain unclear. In many cases, invasive species exhibit fundamental behavioral changes during or immediately following introduction. The introduction of the Argentine ant (*Linepithema humile*) to North America has caused a variety of economic, agricultural, and ecological problems. These problems are a direct result of the unusual behavior and social organization that characterizes introduced populations of Argentine ants: In their introduced range, Argentine ants are unicolonial, forming massive "supercolonies" that can extend for thousands of kilometers. Here, I describe our studies of the genetic and chemical basis of social behavior and colony organization in the invasive Argentine ant. We have found that genetic homogenization of introduced populations had produced correlated homogeneity in the chemical cues that Argentine ants use to recognize nestmates. Thus, nearly all introduced Argentine ants perceive each other as kin, and form large, cooperative supercolonies. More recently, we have identified, synthesized and tested the specific chemicals that these ants use as labels of kinship. The combination of information from the fields of genetics, behavior, and chemical ecology has provided unique

insights into the causes of success for this species and other damaging invaders, and suggests potential methods of control.

29. TRANSFORMING TAXONOMY FOR EFFECTIVE BIODIVERSITY ASSESSMENT OF ARTHROPODS IN MADAGASCAR

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Madagascar has received immense interest in the arthropod taxonomic community over the last 20 years. Despite the enormous efforts to inventory the arthropods on the island, there have been few taxonomic products. Millions of specimens have been collected but relatively few species have been described. The slowness of the current taxonomic process has had a huge impact in the role insects play in conservation. Madagascar's President, Marc Ravalomanana, has formally committed his government to a massive expansion of the protected areas network, more than tripling the total area. Several million hectares will be designated for inclusion in this new Madagascar System of Protected Areas over the next few years. Unfortunately, insects are not a key player in the analysis of priority areas. If conservation planning efforts focus only on well-known and relatively species-poor taxa, then we risk overlooking significant ecological and evolutionary components of biodiversity. If monitoring efforts overlook insects, we will fail to hear the early warning signs from these canaries in the coal mine. We evaluate the use CO1 barcoding to accelerate both the delimitation and the identification of ants across the island in a study that includes over 6,000 specimens sequenced.

30. CONSERVATION OF HAWAIIAN DROSOPHILA USING PHYLOGENETIC, ECOLOGICAL AND POPULATION GENETIC DATA

P. O'Grady

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Hawaiian Drosophila contains an estimated 1000 species and has served as the classic example of rapid speciation in nature. In spite of this impressive diversity, invasive species and anthropogenic effects are having an impact on both species diversity and population size. We use an approach that integrates an historical phylogenetic perspective with ecological and population genetics to address the management of Hawaiian insect diversity.

31. USING PHYLOGENY TO EXAMINE THE OPTIMAL SCALE OF INSECT CONSERVATION IN REGIONS WITH HIGH LEVELS OF ENDEMISM

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Insects are rarely the focus of conservation efforts, taking a backseat to vertebrates and plants under most circumstances. As a result, little is often known about the patterns and scale of endemic insect genetic diversity or the impacts conservation plans designed for other organisms may have on rare insects. Using examples of endemic *Hyposmocoma* moths from Hawaii and the federally listed *Euproserpinus* from California I present phylogeographic patterns of genetic diversity, based on mitochondrial and nuclear DNA markers, and contrast these with current conservation planning. Moth diversity tends to be on a much finer spatial scale than most conservation preserves, sometimes even when the insects are federally listed. If changes are not undertaken in the way conservation is practiced, endemic species of insect are likely to disappear, and even species that have legislative protection may lose significant portions of their genetic diversity.

32. TERRESTRIAL ARTHROPOD DIVERSITY OF MOOREA: A MODEL ECOSYSTEM

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Arthropod biodiversity surveys and inventories present unusual obstacles, including funding and systematics expertise. Here, we describe a survey of the terrestrial arthropods of the French Polynesian island of Moorea. This project is funded through a traditional NSF Biodiversity Survey and Inventory and a non-traditional DNA barcoding effort from the Gordon and Betty Moore Foundation. The Moorea Biocode Project (MBP) is an integrated approach to biodiversity science that bridges the gap between ecology, genomics, and systematics. The goal is to put in place the conditions necessary to achieve radical advances in the way we monitor and manage ecosystems and conserve biodiversity. One objective of the project is to generate a vouchered, All Taxon Barcode Inventory (ATBI) for the tropical island of Moorea, French Polynesia. A complementary objective is to build the identification tools needed to access this inventory. A fundamental principle of the MBP is to ground the development of informatics in real-world experience. Thus, computer scientists and informatics experts are working directly in conjunction with field, laboratory, and museum researchers, to ensure that solutions are user-driven and practical. In a pilot study (Dec 2005-June 2007) we catalogued approximately 30% of the known diversity for the Moorea ecosystem, including both marine and terrestrial species. We describe the details of the project, collaborations, successes, pitfalls, and prospects for the future.

33. POTENTIAL HABITAT FOR QUINO CHECKERSPOT BUTTERFLY UNDER ALTERED CLIMATE CONDITIONS: IMPORTANCE OF BIOTIC INTERACTIONS

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The Quino checkerspot butterfly (*Euphydryas editha quino*) is a federally-endangered species that historically was one of the most abundant and widespread butterflies in southern California. Much of the butterfly's former range has been developed or converted to agriculture and remaining natural areas supporting Quino checkerspot are in degraded condition. Habitat degradation is attributed to habitat fragmentation, invasion by annual grasses, altered wildfire regimes, and other anthropogenic disturbances. The butterfly is now confined to San Diego and Riverside Counties and a few locations in Baja California, Mexico. Quino butterflies occur in open shrublands (coastal sage scrub, chaparral, and desert transition) with sparse non-native vegetation. The presence of primary larval host plant populations (*Plantago erecta* and to a lesser extent *Antirrhinum coulterianum*) are essential for reproduction. Predicting changes in potential habitat for endangered species as a result of global warming requires considering more than future climate conditions, it is also necessary to evaluate biotic associations. Most distribution models predicting species responses to climate change include climate variables and to lesser extent topographic and edaphic parameters; rarely are biotic interactions included. We present a niche modeling approach that incorporates both biotic interactions and climate change into niche models predicting suitable habitat for this species.

34. HONEY BEES AND COLONY COLLAPSE – WHAT IS IT?

Eric Mussen

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Colony Collapse Disorder – Beekeepers across the nation have nedured winter losses of 5-10% of their colonies since honey bees were imported in the 1620's. In the 1980's, two exotic parasitic mites were introduced into the country and expected winter losses climbed to 20 –25%. Although honey bees have an amaing ability to build colony populations from small beginning populations, 25% annual losses are the maximum the beekeepers can regularly experience and still remain in business. Over the last four years, many beekeepers have lost 30- 100% of their colonies between late summer and spring. Those losses, where the adult bee population simply flies away over a short period of time, leaving behind the queen, a few young worker bees, stored food and sometimes brood, is called colony collapse disorder (CCD).

35. IMIDACLOPRID AND THE NEONICOTINOID INSECTICIDES - ASPECTS RELATING TO HONEY BEES AND COLONY COLLAPSE

Alison Chalmers[1], David Fischer[1], Christian Maus[2], Richard Schmuck[2] and David Rogers[1]

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Neonicotinoids are a novel class of insecticides with a more favorable environmental and toxicological profile than the previous broad-spectrum insecticide chemistry. Their efficacy against difficult-to-control pests combined with their application flexibility and low mammalian toxicity has led to rapid adoption into a variety of markets worldwide. Some neonicotinoids are, like most insecticides, intrinsically toxic to honeybees, but the possibility of exposure to bees has been effectively minimized through formulation and application methodologies.

Recent health problems occurring in bee colonies in the US (e.g. colony collapse disorder) have led to increased scrutiny of many factors, including insecticides. Imidacloprid was the first member of the neonicotinoid class, and as such, has been studied extensively with regard to bee safety. In this presentation we will review the available literature on imidacloprid and bees and discuss the science behind the risk assessment. This will include an overview of the mode of action of imidacloprid, and a discussion of field studies in a number of different crops. These studies include measurements of residues in plants after soil and seed treatment, and detailed studies of the behavior and health of bees in imidacloprid and other neonicotinoid-treated crops. All these studies support the conclusion that neonicotinoids are not a factor in causing colony collapse.

36. ACCUMULATION OF SYSTEMIC INSECTICIDES IN NECTAR

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The systemic insecticide imidacloprid is widely used to control a variety of insect pests. The objective of the research program was to determine if the insecticide injected into the soil at the base of eucalyptus trees accumulated in the floral nectar of the trees and could this impact hymenopteran parasitoids. The soil was injected at label rates based on tree diameter and the nectar was sampled when the trees bloomed six months after treatment. In a parallel study, LC_{50} values were determined for two parasitoids of the eucalyptus longhorned borers. Analysis of the nectar for imidacloprid concentrations showed they exceeded the LC_{50} values for the egg parasitoid, *Avetianella longoi*, but not for the larval parasitoid, *Syngaster lepidus.* Feeding trials with the nectar also showed that the insecticide changed parasitoid oviposition behavior and fecundity. If hymenopteran pollinators show similar responses, the high concentrations of pesticide residues in eucalyptus nectar may have impacts on foraging pollinators and on reproductive success.

41. PHYLOGENY OF PTEROSTICHINE GROUND BEETLES: AUSTRALIAN LINEAGES AND THE ORIGINS OF BROODING BEHAVIOR

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Phylogenetic analysis of DNA sequence data from exemplars representing the diversity of Pterostichini auct. (Carabidae: Pterostichini) worldwide and a broad sample of exemplars of other tribes in Harpalinae does not support a monophyletic Pterostichini. However, there are several large clades that are well supported and these include trans-Gondwanian sets of taxa. These clades are composed in part by Australian taxa and among some of these Australian species burrow-making and brooding behaviors are known. Such behaviors have originated independently several times in pterostichines and probably multiple times in Australian taxa. Behaviors that include aggregations of larvae are uncommon in Carabidae as most larvae are truculently predacious and probably even cannibalistic. We describe new observations on the life history, burrow-making and brooding behaviors in some *Nurus* species and compare this to what is presently known regarding similar behaviors in other Australian and New Zealand species and to distantly related species from the Northern Hemisphere.

42. IDENTIFICATION OF CHEMOSTIMULI FROM NATURAL HOST SUBSTRATES AND THEIR RECEPTORS FOR NAVEL ORANGE WORM ADULT MOTHS, *AMYELOIS TRANSITELLA* (WALKER) (LEPIDOPTERA : PYRALIDAE)

Zainulabeuddin Syed and Walter S. Leal

Honorary Maeda-Duffey Laboratory, Department of Entomology, University of California-Davis, Davis, CA 95616

Chemostimuli from hosts are utilized by female moths as cue for potential egg laying sites. There is also evidence of plant compounds modulating the pheromone perception in males. We collected headspace volatiles from almond shoots and navel oranges, two produce that are regularly damaged upon female oviposition and subsequent larval hatching by Navel Orange worm (NOW) moths. Volatiles were collected by various methods, were resolved by capillary Gas Chromatography (GC), and the eluting peaks were detected – simultaneously – by a chemical Flame Ionization Detector (FID) and female insect antenna, a technique commonly referred as GC-linked elctroantennographic detection (GC-EAD). By employing this GC-EAD technique we identified a range of stimuli that consistently elicited antennal responses from females. We further looked at the reception of these novel chemostimuli by a rather sensitive and selective technique, called single sensillum recordings (SSR). Various sensilla type housed neurons that displayed high sensitivity to the volatiles identified from headspace odors of natural substrates that are infested by NOW. Some of these newly identified odorants elicited antennal responses that were comparable, and even higher, to the phenyl propionoate, a gold standard chemostimuli for NOW. Further, a specific sensillum was identified that housed two Olfactory

Receptor Neurons (ORNs): one detecting phenyl propionoate and the other responding with significantly higher sensitivity to one of the newly identified chemostimuli respectively.

43. NAVEL ORANGEWORM DISPERSAL AND ABUNDANCE IN ALMONDS AND PISTACHIO

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The navel orangeworm (NOW) is the most important insect pest of almonds and pistachios in California. The development of mating disruption for control of this pest would benefit from information about dispersal and abundance. In 2006 and 2007, studies were conducted to examine movement and abundance of NOW within pistachios, between pistachios and almonds, and between almonds under mating disruption and almonds under an insecticide program for control of NOW. We used three techniques to examine movement and abundance: protein mark-capture (marked feral moths), mark-release-recapture (marked laboratory reared moths), and damage analysis from transects on the edges of adjacent plots. The marking studies showed that navel orangeworm abundance was lower in early July in both pistachios and almonds compared to late April and early August, but that abundance was greater in pistachios than in almonds in all three periods. Both marking methods indicated dispersal capability of at least 1000 meters in 24-72 hours. Patterns of dispersal from marked areas were consistent with both techniques for both sexes. Damage analyses suggest that while individual NOW of both sexes can travel great distances, in tree nut orchards most oviposition and damage occurs closer to where NOW females emerge from pupae to adults. Under the conditions observed in these studies, random diffusion is probably the greatest factor on net movement of NOW between pistachios and almonds.

44. TALES FROM A COUNTY ENTOMOLOGIST: ENTOMOLOGY FROM A REGULATORY PERSPECTIVE

Brian J. Cabrera and Guy Tingos

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One of the main objectives of the Agricultural Commissioner's Office is to prevent pests from becoming established in the county, especially in agricultural regions and ornamental and floral nursery properties. We do this primarily by regulating the commercial and private transport of plant materials into and out of the county. Any infested or prohibited shipments we find are subject to regulatory action. We also carry out surveys to detect exotic insects and have the authority to conduct regulatory actions or eradication on incipient infestations. We collaborate with state and federal agencies on biological control of established exotic pests. Our office also

provides required certification for receiving states or countries verifying that plants exported from our county are free from certain insects and diseases. In addition, we identify arthropods and mollusks brought in by private citizens, pest control companies, PCAs, and others. The county entomologist plays an active role in these activities and as a result encounters an interesting and fascinating array of agricultural, ornamental, medical, and urban pests. We will discuss the unique work of the county entomologist and give examples of some of the interesting entomological issues our office has dealt with in the past year.

45. A NEW WHITEFLY-TRANSMITTED DISEASE IN CALIFORNIA: CUCURBIT YELLOW STUNTING DISORDER

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Cucurbit yellow stunting disorder like-symptoms were found in Southern California cucurbit crops in the fall of 2006. The presence of *Cucurbit yellow stunting disorder virus* (CYSDV) in cucurbits was verified using RT-PCR; the first find in California. RT-PCR also verified that *Bemisia tabaci* (Genn.) was carrying the virus. It was critical to limit its spread and to develop a management strategy to protect cucurbit crops because CYSDV has the potential to cause devastation. A cucurbit variety trial was used to screen for resistance to CYSDV. A survey was conducted in melon fields during the spring and fall of 2007 to define the geographic area with CYSDV. Because the only known (non-experimental) hosts of CYSDV were species in the Cucurbitacea family, we made recommendations about establishing a host-free period during the summer to prevent severe damage to fall cucurbit crops and to prevent the further spread of CYSDV. Non-Cucurbitacea weeds and crops were screened as potential hosts of CYSDV. The spring survey established that the virus had overwintered or been reintroduced in spite of a severe frost the previous winter. Fall melon crops in Southern California were again infected with CYSDV, but growers were able to produce fruit of market quality. Lettuce has been listed as an experimental host of CYSDV; from Imperial Valley field specimens, we were able to verify that Romaine lettuce is a host for CYSDV. Romaine lettuce is potentially an important CYSDV overwintering bridge between the spring and fall melon crops.

46. EFFECTS OF PRE-WINTERING AND WINTERING DURATIONS ON ADULT EMERGENCE OF ALFALFA LEAFCUTTING BEES

Theresa L. Pitts-Singer, and Rosalind R. James

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Use of *Megachile rotundata*, the alfalfa leafcutting bee, as a pollinator of alfalfa greatly enhances the seed yield. Management of bees differs among bee managers, including how bees are

handled prior to wintering, and how long they remain at an over-wintering temperature. In this study, we investigate whether the duration of pre-wintering and wintering affects the weight, percent water content, and percent lipid content of the bee prepupae, and if there are effects on the survival, emergence duration, sex ratio, weight, and longevity of adult bees after spring incubation. Some effects were found, and future research on pre-wintering duration and temperatures may help to devise management strategies for both pre-wintering and wintering periods in an effort to yield healthy commercial populations of alfalfa leafcutting bees in the U.S.

47. SUSCEPTIBILITY OF OLIVE FRUIT IN RELATION TO OLIVE FRUIT FLY DEVELOPMENT AND OVIPOSITIONAL PERIOD IN CALIFORNIA

Victoria Y. Yokoyama

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Olive fruit fly, *Bactrocera oleae* (Gmelin), females oviposited their first and last eggs in olive fruit, *Olea europaea* L., when females were 6 and 90 d-old, respectively. The highest mean numbers of eggs per day in 10 olive fruit (55) were oviposited by 28 d-old females, and peak egg production occurred when females were between 13-37 d-old. The susceptibility of six size groups of immature olive fruit to oviposition and larval infestation by olive fruit fly was studied in laboratory cage tests. Fruit height from the stem to the blossom end was a more reliable method to separate the sizes than the calculated fruit volume (1/6 x height x diameter^2). A significantly greater number of ovipositional sites occurred in all sizes of immature green fruit when exposed to adults in cages for 5 d versus 2 d. The number of adults that emerged from the same fruit was similar for both exposure periods. Adults emerged from fruit exposed to oviposition in size groups with a height of $\geq$1.0 cm or a volume of $\geq$0.2 cm^3.

48. DEVELOPMENT OF MANAGEMENT PROGRAMS FOR CITRUS THRIPS IN CALIFORNIA BLUEBERRIES

David Haviland and Stephanie Rill

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In recent years citrus thrips has become the most important pest of blueberries in California. Feeding by thrips causes distortion, discoloration, stunting of new shoot growth, and damage to the development of fruiting wood that results in the next years crop. In this presentation we will present data on the progress to date towards developing an IPM program for this pest. This includes information on general pest biology, population dynamics, recommended monitoring programs and documentation of thrips impact on yield and fruit quality. We will also discuss the status of chemical control programs and their alternatives, such as the use of high pressure water and fungal pathogens for pest suppression.

49. HAWAIIAN PROSPECTS FOR THRIPS CONTROL USING THE WHITE MUSCARDINE FUNGUS

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Beauveria bassiana (Balsamo) Vuillemin is a generalist entomopathogenic fungus found worldwide. Commercial strains of *B. bassiana* have the potential to provide good control of certain insect pests in Hawaii, including thrips, which are serious pests on orchids because of insecticide resistance. Although strains of *B. bassiana* are already present in Hawaii, state quarantine regulations prohibit the use of imported biopesticides containing this fungus because of concerns that native insect populations might be adversely affected by exotic fungal strains. We cultured and genetically fingerprinted fourteen strains of *Beauveria bassiana* collected from insects in Hawaii. The virulence of these strains was compared in bioassays with the GHA strain which is used commercially as a biopesticide in the continental USA. Based on results using selected insect species in four different orders, we found no evidence to support the hypothesis that the GHA strain of *B. bassiana* represents a greater risk to native insects than the strains already present in Hawaii.

50. LYGUS HESPERUS MOVMENT AT THE LANDSCAPE LEVEL: ARE OUR "TRADITONAL" CONCEPTS ACCURATE?

Peter B. Goodell and Doug Cary

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Lygus hesperus is a key pest in multiple crops in the Westside of the San Joaquin Valley of California. In addition, many plants can act as hosts for population development and eventual movement into susceptible crops such as dry beans, cotton and seed alfalfa. The concept proposed by Vern Stern in the 1960's described the landscape components as sources from which Lygus move or sinks into which Lygus accumulate. In 2007, as part of a USDA-CREES RAMP grant, 41 focus cotton fields across approximately distance of 70 miles were sampled weekly in four quadrants from June through September. Surrounding crops and focus cotton fields were georeferenced and mapped into a GIS data base. Surrounding crops were sampled but less frequently than the focus cotton fields. As expected, cotton located adjacent to crops known to be high risk for Lygus populations (seed alfalfa, safflower, sugar beets, weedy fields) had higher adult populations then those cotton fields surrounded by cotton. Alfalfa hay could serve as a source or a sink depending on how the fields were harvested. As more safflower is planted in this area, the question of the accuracy of our understanding of Lygus population development on safflower has been questioned.

51. EFFECT OF DELAYED FEMALE MATING ON REPRODUCTIVE BIOLOGY OF CODLING MOTH AND OBLIQUEBANDED LEAFROLLER

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Delay of mating was examined as a possible mechanism for population decreases associated with mating disruption for codling moth, *Cydia pomonella* (L.), and obliquebanded leafroller, *Choristoneura rosaceana* (Harris) (Lepidoptera: Tortricidae). We delaying female mating 0, 2, 4 or 6 d while holding male age constant and examined life table parameters of both species. Increasing delays resulted in an increase in percentage of sterile pairs, and a reduction in net reproductive rate unrelated to sterility. Percentage-wise, OBLR population growth was more strongly affected than CM. However, OBLR net fertility rate was ≈8x higher than that of CM, so that OBLR females that experienced a 4 d delay in mating had nearly the same reproductive rate as CM females that experienced no delay. Simulations showed that CM females experiencing >2 d delay in mating resulted in decreased population density or extinction within 2 generations. In contrast, OBLR females delayed <6 d showed rapid population growth that decreased as female age at mating increased; only the 6 d delay treatment resulted in decreased population levels. Our data thus suggests that delay of mating plays a greater role in CM mating disruption than for OBLR.

52. SITE-SPECIFIC CODLING MOTH MANAGEMENT IN TREE FRUITS

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Site-specific management of codling moth, *Cydia pomonella* L., can allow growers to reduce their costs by substituting increased monitoring inputs for reductions in insecticide applications. Action thresholds have been developed using pear ester and sex pheromone lures to reliably predict the occurrence of both low (≤ 0.3%) or high levels (> 0.3%) of fruit injury at harvest. The use of these lures in optimized traps has dramatically reduced the occurrence of 'false-negative' indications by traps. Increasing the density of traps along orchard borders is required to adequately monitor these regions due to their greater potential for fruit injury. Conversely, the density of traps can be reduced in the center of large orchard plots. Off-the-shelf hardware is now available that can be interfaced with simple software programs to facilitate the collection and summary of data and their use to spatially adjust treatment applications. An overview of the various pieces of a fully operational system that we are developing will be presented.

53. NATIVE HEDGEROWS PROVIDE CONSERVATION AND AGRICULTURAL BENEFITS

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Non-crop areas surrounding farmlands can provide important ecosystem services to agriculture including pollination, erosion control, and water quality protection. More recently there has been interest in quantifying pest control services that these non-farmed areas may provide to adjacent crops. We examined established, planted native hedgerows and weedy unplanted areas in northern California for beneficial and pest insects assemblages, over two growing seasons. Beneficial and pest insect abundance was compared within each vegetation type (shrub, grass, and weed) from spring to fall using a full factorial mixed model ANOVA. Native hedgerow shrubs supported a larger abundance of beneficial than pest insects throughout the growing season. In addition, the proportion of beneficial to pest insects was greater in native shrubs, and to a lesser extent, native grasses, than in adjacent weedy areas. The consistently low abundance of pest insects and high number of beneficial insects on shrubs throughout the growing season, along with evidence that beneficial insects move from hedges into crops suggests that the established hedgerows in our study could provide pest control benefits to adjacent crops. Valuation of ecosystem services that non-crop areas can provide to agriculture may be one way to promote conservation programs on farms to help conserve biodiversity.

54. MANAGING SCIRTOTHRIPS SPECIES IN CALIFORNIA AND ARIZONA WITH SPINETORAM, A NEW SPINOSYN INSECTICIDE

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Spinetoram is a new broad spectrum spinosyn insecticide that was recently registered in the United States. It is derived from naturally occurring spinosyns that are chemically modified to increase insecticidal activity. Field and greenhouse studies conducted in California and Arizona over the past four growing seasons have shown it to be effective in managing citrus thrips, *Scirtothrips citri* (Moulton), in oranges, lemons, blueberries, and laurel sumac. Field studies in California have also shown that spinetoram controls avocado thrips, *Scirtothrips perseae* (Nakahara), in avocados. Research results demonstrate that Spinetoram is an important new tool for managing these thrips in key high value permanent crops.

55. SEASONAL FLIGHT PATTERNS AND GEOGRAPHIC DISTIBUTION OF CLICK

BEETLES FROM POTATOES IN ALASKA

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In the United Sates and Canada, wireworms (Coleoptera:Elateridae) are important pests of vegetables, small grains, and potatoes (*Solanum tuberosum* L.). In Alaska, wireworm damage to potato has been noted as early as 1949. However, there is no consensus of the importance of the group or the species composition affecting agricultural crops in Alaska. This work reports on the taxonomic identity and flight patters of click beetles in Alaska. Adult elaterids associated with potato production were collected in the three major potato producing areas of Alaska: Fairbanks, Delta Junction, and Palmer and from a subsistence farm above the arctic circle in Wiseman. Twelve species from ten genera were collected including three of the six most economically important genera in terms of potato production in the USA (i.e., *Ctenicera, Hypnoidus,* and *Limonius*). Ninety-seven percent of the specimens collected belong to two genera: *Hypnoidus* and *Limonius*. Forty-eight percent of the specimens were collected from the Palmer area, 37% from Fairbanks, and 14% from Delta Junction. Only five specimens were collected from Wiseman. Data on population dynamics and geographic distribution will be presented.

56. INTERACTIONS BETWEEN THE POTATO APHID AND ITS HOST PLANTS IN IDAHO'S POTATO ECOSYSTEM

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The potato aphid (PA) Macrosiphum euphorbiae (Thomas) is highly polyphagous and feeds on over 200 host plants. However, in Idaho it shows a distinct preference for hairy nightshade (HNS) Solanum sarrachoides (Sendtner) plants. Hairy nightshades are known to serve as virus-reservoirs. Potato aphid and the green peach aphid (GPA) Myzus persicae (Sulzer) are known to efficiently transmit viruses from hairy nightshade to potato. Biology-experiments performed with lab-reared PAs indicated that aphids survived only on HNS when compared to five other hosts that included potato. The same experiment conducted with field-collected aphids yielded similar results. Attempts to raise a PA colony on hosts other than HNS were unsuccessful. These results indicate that the exhibited monophagy is probably due to the existence of a new host-specific strain. Other experiments indicated that PAs have a higher innate ability to produce winged aphids than GPA even under non-crowded conditions. The PA is also more mobile than GPA. These two factors may increase the transmission ability of PA and consequently this aphid could play a major role in viral-epidemiology. The results of these and other PA biology and behavioral experiments and the implications of unique PA host-utilization patterns will be presented.

57. **EFFECTS OF SEED TREATMENT INSECTICIDES ON CEREAL LEAF BEETLE IN WHEAT.**

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Cereal leaf beetle, *Oulema melanoplus*, over winters as adult females in grasses. In early April, the females enter fall seeded wheat and begin to oviposit eggs onto wheat leaves. Larvae emerge and begin feeding resulting in the leaf striping consider damage from this insect. A trial consisting of RCBD winter wheat with 4 replicates allowed counts of CLB larvae per meter square. The All Pairwise Comparison LSD t Test showed high rates of Neonicotinoid insecticides reduced CLB populations until anthesis at which point the surviving CLB adults migrated to spring cereals

59. GLASSY-WINGED SHARPSHOOTER AREA-WIDE MANAGEMENT IN THE SAN JOAQUIN VALLEY, CA.

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The area-wide management of Glassy-winged Sharpshooter (GWSS) in the San Joaquin Valley has been a successful undertaking. Beginning in 2001 and continuing today, GWSS populations in agricultural areas have been suppressed in Kern and Tulare Counties. Treatments have targeted citrus, where GWSS prefers to overwinter. The coordinated timing of treatments on this one commodity has allowed the program to effectively suppress GWSS populations while not flooding the system with pesticides on multiple commodities. This suppression effort has allowed grape growers to incur fewer losses due to Pierce's Disease, as well as to allow citrus growers the ability to move their bulk citrus loads without restriction by State regulations. An update on past, present and future will be provided.

60. MANAGING THE GLASSY-WINGED SHARPSHOOTER AND THE VINE MEALBUG IN VINEYARDS WITH NEONICOTINOID INSECTICIDES

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Experiments and field demonstrations over the past six years have shown that systemic neonicotinoid insecticides are effective against the glassy-winged sharpshooter (GWSS), *Homalodisca vitripennis,* and the vine mealybug (VMB), *Planococcus ficus.* The uptake of the

neonicotinoid insecticides, imidacolprid (Admire/AdmirePro), thiamethoxam (Platinum) and dinotefuran (Venom) into grapevine xylem was studied and compared in vineyards located in Coachella, Napa and Temecula valleys. The studies have shown that uptake is dependent upon the interactions between the insecticides, and the local soil and climatic conditions. In Napa, where there is minimal irrigation, imidacloprid uptake was poor due to heavy clay soil conditions, which bind the insecticide. Better uptake of the more water-soluble dinotefuran was achieved in Napa and this neonicotinoid may provide vineyards in that region with a more effective management tool for the control of Pierce's disease vectors and vine mealybug. In terms of concentration of active ingredient in the grape vine xylem fluid, differences do occur among the neonicotinoids when applied at similar rates. When imidacloprid, thiamethoxam and dinotefuran are applied under optimum conditions of soil and irrigation they all provide protection against GWSS and VMB, but local agronomic factors can compromise their efficacy.

61. CONNECTING THE DOTS: VECTOR TRANSMISSION OF *XYLELLA FASTIDIOSA* AND PIERCE'S DISEASE EPIDEMIOLOGY

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The dynamics of insect-borne diseases are governed by the interplay of a variety of biotic and abiotic factors. We studied some of these factors that are expected to be important to the epidemiology of Pierce's disease (PD) in California vineyards. We conducted a series of greenhouse transmission experiments to quantify how sharpshooter species, sharpshooter number, inoculation period, and temperature affect transmission of *Xylella fastidiosa* to grapes and PD symptom development. Interestingly, larger numbers of vectors and longer inoculation periods increased the onset of PD symptoms. In another experiment we looked at the relationship between temperature and transmission efficiency; high temperature (30C) resulted in low vector survival yet marginally higher infection rate. Moreover, *X. fastidiosa* concentration in vines was positively related to the number of vectors that tested positive using realtime PCR. These results suggest that high sharpshooter loads may not only increase transmission rate but also decrease incubation period – presumably because of a larger inoculum. We expect that high vector densities and temperatures will increase the rate of disease cycling, which is particularly relevant to disease prevalence in this system. We also incorporated some of these factors into mathematical models to evaluate their potential importance as drivers of PD epidemics. These results provide tools that may be used to forecast the impact of different control practices on limiting PD spread.

62. MAPPING POST-WINTER GLASSY-WINGED SHARPSHOOTER POPULATIONS IN CALIFORNIA

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After the glassy-winged sharpshooter (GWSS), *Homalodisca vitripennis* (Germar)(Hemiptera: Cicadellidae), arrived in California, it was believed that the insect would establish throughout much of the northern agricultural production areas. However, GWSS appears to be limited to discrete regions within California where winter temperatures are mild. Prior research indicated that GWSS adults cannot feed at temperatures below 50°F (10°C), thereby reducing its ability to survive cold winters in locations where the maximum daily temperatures remain below 50°F for long periods (e.g., weeks). Currently, we are exposing GWSS adults to programmed temperature regimes that simulate temperatures recorded at various sites around California where winters vary from mild to cold. Results from these studies should verify the relationship between cumulative cooling degree days and GWSS overwintering mortality. Using state-wide temperature records to calculate numbers of cooling degree days, we are constructing GIS maps to delineate areas where post-winter GWSS mortality should be substantial, thereby providing a tool to estimate the springtime GWSS threat to different regions. Our work is directed towards predicting regions where the need to manage springtime populations of GWSS will be the greatest, thereby allowing better usage of resources allocated for GWSS management.

63. NON-TARGET IMPACTS OF THE GLASSY-WINGED SHARPSHOOTER PARASITOIDS: GOOD NEWS FOR GRAPES?

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A retrospective study was conducted to evaluate possible non-target impacts of egg-parasitoids released for control of the glassy-winged sharpshooter, *Homalodisca vitripennis* (Germar) (Hemiptera: Cicadellidae), in a classical biological control program. Specifically, the solitary *Gonatocerus ashmeadi* Girault and the gregarious *G. fasciatus* Girault (Hymenoptera: Mymaridae) physiological and ecological host ranges were estimated on three non-target indigenous sharpshooters, the smoke-tree sharpshooter, *Homalodisca liturata* Ball, the blue-green sharpshooter, *Graphocephala atropunctata* (Signoret), and the green sharpshooter, *Draeculacephala minerva* Ball (all Hemiptera: Cicadellidae). During this evaluation significant non-target impacts were revealed in both laboratory experiments and field observations.

Implications of non-target impacts will be explored, including the exploitation of them as an integrated component of grape pest management.

64. CONVENTIONAL AND ORGANIC MITE MANAGEMENT IN WINEGRAPE VINEYARDS

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Pacific and Willamette spider mites are common in California vineyards. Although the Pacific mite is considered more problematic, both species can require that management actions be taken to avoid economic losses. Until recently, conventional miticides were limited to products such as dicofol (Kelthane), propargite Omite and fenbutatin oxide (Vendex). The utility of these products became somewhat limited because of mite resistance to the chemicals and extended preharvest intervals. During 2006 and 2007, registered and candidate conventional and OMRI-approved organic miticides were evaluated in separate experiments conducted in San Joaquin County and El Dorado County winegrape vineyards. Conventional miticides included abamectin (Agri-mek), etoxazole (Zeal), fenpyroximate (Fujimite), pyridaben (Nexter), spirodiclofen (Envidor), acequinocyl (Kanemite), bifenazate (Acramite), (Onager), propargite, and horticulutral mineral oil. Organic miticides included Organic JMS Stylet Oil, GC-Mite, Ecotrol, Organocide, and M-pede. Results of season long monitoring of spider mites, grape leafhopper and powdery mildew incidence under various organically acceptable powdery mildew management regimes are also reported.

65. BIOLOGY AND IPM OF ERIOPHYID MITES IN OREGON VINEYARDS

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It is believed that Short Shoot Syndrome (SSS) is directly caused by rust mites *Calepitrimerus vitis* (Nalepa) feeding on rapidly developing buds at the onset of early season growth. Severe crop losses as high as 49 %, were reported in Oregon vineyards. These losses are due to bunch necrosis, a symptom of SSS during the early part of the season. Other symptoms include malformed leaves, unusually short and angled shoots, scar tissue and bronzed leaves close to harvest time. During winter, rust mites are dormant and no evidence of direct bud damage from rust mites was found inside dormant buds. Tissue damage from mites feeding on rapidly developing tissue was however first observed between bud break and the two-leaf stage in mite

infested vineyards. Spray trials were conducted in order to determine optimal timing for control of these mite populations. Data suggest that two sprays targeted during the wooly bud stage and two weeks later limited crop losses. The heavy reliance on sulfur sprays may be one of the contributing factors for mite population explosions. Some alternatives to the current spray regime are discussed.

66. NO RAIN, COLD WINTER. THE TERROIR OF SUCCESSFUL IPM IN WASHINGTON VINEYARDS.

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In Prosser, WA December, January, and February average low temperatures are -3º, -4º, and -2º C, respectively. Precipitation averages 19 cm per year and no month has an average precipitation greater then 2 cm. Over 90% of the wine grapes are deficit drip irrigated during the growing season. These weather conditions have proved to be uninviting to the plague of exotic pests that have recently colonized vineyards in milder climates due south. Over the past 10 years we have observed a tremendous increase in IPM adoption in Washington vineyards. Prior to 1998 climbing cutworms were the key arthropod pests in Washington vineyards. Walsh developed a technique of spraying only the area where the vine trunk and trellis meet the soil. This targeted "barrier treatment" keeps cutworms on the ground and off the vines. It works with a variety of pesticides, but pyrethroids have become the industry standard. This technique alone has eliminated the use of OPs in Washington State vineyards. This has enabled grape growers to rely on conservation biological control for most other vineyard pests and we can document a reduction in insecticide and miticide use of 84% per acre between 1996 and 2006.

Powdery mildew in the 1990's was controlled with calendar-based applications of sterol-inhibiting (DMI) compounds and sulfur. Grove's plant pathology research has resulted in a shift to the use of oils and new, reduced-risk fungicides and the adoption of weather-based disease forecasting models. The wholesale adoption of weather-based disease management has resulted in a 74% reduction in the use of synthetic fungicides for mildew control over the past 10 years.

67 YELLOW STARTHISTLE: A BIOCONTROL PROJECT WITH MANY TWISTS AND TURNS

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Dilemmas, difficulties and unforeseen events, punctuated by periods of marked success, have characterized the yellow starthistle (YST) biocontrol program since its beginning in the 1950s

when livestock ranchers requested that the University of California (Division of Biological Control) initiate a program. The conflicting interests of ranchers and California beekeepers were resolved in 1959 and the program commenced, with a seedhead fly from Italy (called *Urophora sirunaseva*) the first agent introduced (1960s, 1970s) in the U.S. In the 1980s, European-based research showed that the fly assumed to be *U. sirunaseva* (*U. jaculata* was actually released due to taxonomic confusion) failed to establish on North American YST populations. Also in the 1980s, the YST program was at the forefront in the development and acceptance of open-field tests in host-specificity determination of insects for biocontrol of weeds. These tests were necessary to clear *Eustenopus villosus* and *Larinus curtus* for release in the U.S., two agents originally disqualified as potential candidate agents. And the author's early concerns about the host-specificity of *Ceratapion basicorne*, a root crown insect, were resolved after open-field testing and other research. Not to be overlooked, as well, was the 1983 terrorist attack of the USDA-ARS Biocontrol Laboratory, Rome, Italy, which delayed progress by YST researchers. Moreover, the YST program is associated with the accidental release and establishment of an unapproved (*Chaetorellia succinia*) agent in the U.S. Finally, this paper addresses other 'lessons learned' from the YST program (selection of candidate agents, potential for interspecific competition by introduced agents, administrative decisions), which together with the aforementioned challenges and events can help improve the conduct of other biological weed control programs.

68. ARE SEED-FEEDING INSECTS ADEQUATELY CONTROLLING YELLOW STARTHISTLE, *CENTAUREA SOLSTITIALIS*, IN THE WESTERN U.S.?

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Top-down regulations of herbivore insects attacking non-reproductive parts of plants has been documented in the literature but the role of seed-feeding insects in the regulation of invasive plant populations is still debated. A classical biological weed control program initiated against yellow starthistle (*Centaurea solstitialis*) in the 1960s has resulted in the establishment of six Eurasian seed-feeding insects in North America. Because of the number of seed-feeding herbivores introduced, and the fact that no insects attacking other plant parts were introduced, yellow starthistle offers a unique opportunity to study the potential of individual or multiple seed-feeding herbivores to regulate populations of this herbaceous, seed-unlimited, and annual Asteraceae. We conducted a two-year insect exclosure study in the Hell's Canyon ecosystem, located along the Idaho and Oregon state border, to evaluate the individual and combined attack efficacy and control potential of yellow starthistle seed-feeding insect herbivores. Despite combined larval attack rates of up to 94% of available capitula, approximately 9 seeds per attacked capitula escaped herbivory. A combination of adult and larval feeding resulted in a total maximum seed reduction of 70.9% per capitula. We argue that this rate of seed reduction will not regulate yellow starthistle populations because this plant species is not seed-limited. Because of the already high attack rate of available capitula, it is also unlikely that overall seed reduction can be increased. Instead, competitive interactions between insect larvae presently established

are likely to increase. In concordance with earlier findings, we propose that seed-feeding insect herbivores alone are not likely to provide top-down regulation necessary to control non-seed limited invasive plants in their invaded range.

69. BIOLOGICAL CONTROL AS A MANAGEMENT TOOL FOR PLANT COMMUNITIES INFESTED WITH YELLOW STARTHISTLE

Rachel Winston[1] and Mark Schwarzlander[2]
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While few empirical studies examine the direct impact nonindigenous flora have on native species and/or biodiversity, less is known about the indirect effects of biocontrol agents on native plant populations. In the Hell's Canyon ecosystem, there are numerous endemic plant species, some of which are rare, whose habitat has been encroached by yellow starthistle (YST). An understanding of the interspecific effects of YST invasions is crucial for the proper management of this invasive plant and the simultaneous protection of threatened native species. Preliminary results of a long-term plant population study in Hell's Canyon indicate that seed-feeding biocontrol agents reduce the recruitment of YST. However, this reduction does not alter the recruitment of a threatened native species, *C. bakeri* ssp. *Idahoensis.* This and other factors possibly affecting the population of *C. bakeri* ssp. *Idahoensis* are discussed.

70. POPULATION-LEVEL COMPENSATION BY AN INVASIVE THISTLE THWARTS BIOLOGICAL CONTROL FROM SEED PREDATORS

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Predispersal seed predators are often chosen as biocontrol agents because of their high impacts on plant fitness; however, they have a mixed record in realizing decreased plant population growth. Few studies have experimentally removed agents to explore their impact on weed population growth. Here, we used manipulative experiments with invasive yellow starthistle (YST), *Centaurea solstialis*, and its pre-dispersal seed predator biological control agents, primarily *Eustenopus villosus,* the hairy weevil*,* and *Chaetorellia succinea,* the false peacock fly, to explore how these agents affect population growth of YST. We also use additional seed augmentation experiments to mimic effects of agents on seed inputs across a range of seed and adult plant densities.

We found that biocontrol agents reduced seed production by more than 70% and that seedling numbers were significantly related to seed inputs. However, several compensatory processes prevented effective population reduction of YST by seed predators. First, self-thinning reduced seedling numbers such that densities of plants in our agents-present and agents-absent treatments converged. Second, plots in which plants started at low density had particularly high population

growth rates. In this case, plant plasticity and conservation of final yield, in which a small number of large plants produce as much seed as a large number of smaller plants occupying the same area, also provided avenues through which plant populations can compensate for damage. Seed production on a per plot basis was unchanged across a large range of YST densities. Our results suggest that at very low plant densities, biocontrol agents may reduce plant populations; other sources of mortality to YST (imposed after self-thinning)may aid in reducing populations to sizes where agents can become effective tools in weed control.

71. DISTRIBUTION, ABUNDANCE, AND IMPACT OF *CHAETORELLIA AUSTRALIS* AND *C. SUCCINEA* ON *CENTAUREA* SPP. IN WASHINGTON

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Yellow starthistle, *Centaurea solstitialis* (Asteraceae), plants were sampled from multiple sites in each of nine southeastern Washington counties to determine the distribution, abundance, and impacts of the introduced biological control agents *Chaetorellia australis* and *C. succinea* (Diptera: Tephritidae). Yellow starthistle seed heads were collected from 34 sites in the summer of 2004 and dissected to assess fly occurrence. In addition, at 15 sites seed heads were removed from bachelor's button, *Centaurea cyanus*, which acts as an early-season alternate host for *C. australis*, to further characterize the distribution of this fly species. *Chaetorellia succinea* was recovered from all yellow starthistle sites surveyed, infesting 4 to 70% of the seed heads examined per site. Site-wide, the mean number of seed heads infested with *C. succinea* was 23.7%, with four sites having infestations greater than 50%. Flies occurred at higher than expected within-head densities, with nearly half of the infested heads being occupied by 2-8 individuals. *Chaetorellia australis* was identified from 25 of 34 yellow starthistle collection sites, with only four sites having infestation rates exceeding 5%. In contrast, *C. cyanus* collections revealed the presence of *C. australis* at all 15 sites surveyed. Site-wide, 49.3% of the samples bore an indication of immature *C. australis* attack, with infestation levels ranging from 2-88%. Unoccupied *C. cyanus* seed heads produced a mean of 13.08 viable seeds, compared to a mean of 3.08 viable seeds for heads attacked by *C. australis*. Surveys revealed that *C. succinea* is widespread on yellow starthistle in southeastern Washington and infests a considerable proportion of seed heads at some locations, whereas *C. australis* is found more frequently and in greater numbers on *C. cyanus* than on *C. solstitialis*.

72. NONTARGET RISKS OF *CHAETORELLIA SUCCINEA*, AN ACCIDENTALLY RELEASED NATURAL ENEMY OF YELLOW STARTHISTLE

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During our 1995 and 1996 surveys to document the establishment and distribution of one of these agents, the fly *Chaetorellia* (*Ch.*) *australis* Hering (Diptera: Tephritidae), we detected the presence of another, very similar fly, eventually identified as *Ch. succinea* (Costa). We determined that the most probable source of the United States introduction of *Ch. succinea* was a 1991 shipment of yellow starthistle heads from Greece that contained both *Chaetorellia* spp. Flies from this shipment were released at a site near Merlin, Oregon, and both species established there. *Chaetorellia succinea*, but not *Ch. australis*, dispersed widely and rapidly, and the former can now be expected at nearly every yellow starthistle site in California, and is increasing its range in Idaho, Nevada, Oregon, and Washington.

After detecting this 'new' *Chaetorellia* in mid-1996, we immediately curtailed further releases of *Chaetorellia* spp., and began investigating the safety of *Ch. succinea*. We report on more than 10 years of field and laboratory testing that we have completed to determine not only the potential host range in the laboratory, but also the 'realized' host range of this fly in its adventive range.

73. OBSERVATIONS ON THE BIOLOGICAL CONTROL OF YELLOW STARTHISTLE AT TWO LONG-TERM FIELD SITES

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Yellow starthistle, *Centaurea solstitialis* L. (Asteraceae), is an invasive exotic weed infesting over 3 million ha in California. The population dynamics of yellow starthistle and several exotic seedhead insects were studied at two, long-term field sites in central California. Both plant and insect populations were monitored annually for 12 years. Results showed that the overall insect attack rate steadily increased at all sites. The hairy weevil, *Eustenopus villosus*, became the most abundant insect and the fly, *Chaetorellia succinea*, was second in abundance. Both sites showed decreasing trends in seed production, seedling recruitment, and plant density. The decline in plant density was first observed 4-6 years after release.

In a second study, 50 permanent quadrats was established and followed for six years. During

years 4-6, 20 quadrats were treated with the insecticide, imidacloprid, during seedhead production. Results showed no difference in seedling recruitment between treated and untreated plots during the three years prior to the insecticide application. During years 4-6, seedling recruitment steadily declined in the untreated plots while it maintained a constant level in the treated plots. The results suggest that the attack of seedheads by the exotic insects had a significant effect on yellow starthistle seedling recruitment.

74. GEOGRAPHIC ANALYSIS OF THE DISTRIBUTION AND ABUNDANCE OF INSECT BIOLOGICAL CONTROL AGENTS OF YELLOW STARTHISTLE

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Yellow starthistle (*Centaurea solstitialis*) is an invasive, noxious weed that can seriously degrade the quality of grasslands for forage, reduce biodiversity, and change the water budget of ecosystems where it becomes a major component of plant cover. Two exotic seed head insects, *Eustenopus villosus* and *Chaetorellia succinea,* are widespread in California, and their attack rates were measured in 421 locations surveyed in 2001 and 2002. Regression tree analysis and multiple linear regression were performed on the attack rates using a set of climate, land cover, and biological variables. The two methods identified the same variables as the most important predictors of insect attack rates on samples of yellow starthistle taken throughout its range in California. Attack rates of *Eustenopus villosus* were found to be positively related to precipitation levels, negatively related to the distance from a release site, positively related to elevation, and negatively related to relative humidity. Attack rates of *Chaetorellia succinea* were found to be negatively related to the attack rates of *Eustenopus villosus,* and negatively related to precipitation levels. Regression trees were developed independently of location, but the results of the analysis mapped to geographically contiguous regions. The coefficients of the multiple linear regression models also varied by regional subsets created using scatterplots of various climatological values. This work suggests that *Eustenopus villosus* will increase in abundance and impact as it continues to disperse; and shows regions in California where the both species are limited by extrinsic factors.

75. ESTABLISHMENT AND IMPACT OF THE YELLOW STARTHISTLE RUST, *PUCCINIA JACEAE* VAR. *SOLSTITIALIS*

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The yellow starthistle rust, *Puccinia jaceae* var. *solstitialis* is the only exotic plant pathogen approved for release as a biological control on yellow starthistle in North America. The rust is

expected to complement the current and future releases of arthropods used as biological controls. The first release of the rust occurred in 2003 in Napa County California. All stages of the rust life cycle have been documented in the field with multiple generations of urediniospores present in some locations. Large scale production of the rust in a greenhouse made statewide distribution possible in a relatively short timeframe. Over 200 releases have been made throughout the range of starthistle in California. The rust has not persisted well at most sites, reappearing at only 20 % of the sites 12-16 months after release and 10 % of the sites 24-30 months after release. While not widespread, the rust has spread dramatically in a few locations, including one site where the rust spread to almost all plants in a 37 acre area, over a period of two years.

Urediniospores, the infecting stage of the fungus, do not survive for extended periods in the field or laboratory. Teliospores are the longterm survival spores. Appropriate conditions occur in most of California to stimulate germination initiating a new cycle each year. The factors limiting the success of the rust are not yet known, however, high summer temperatures and low moisture may affect both the rust and host plant, limiting the duration of time available for extensive production of both types of spores. With limited spore production the opportunities for successful overwintering decline. Impact studies are in progress. Field impact studies demonstrate that the rust has a substantial impact on leaf life span causing premature senescence. Impacts on plant biomass and seed production have not been demonstrated.

76. DISCOVERY AND EVALUATION OF NEW PROSPECTIVE BIOLOGICAL CONTROL AGENTS FOR YELLOW STARTHISTLE

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Since 1969, six arthropod and one rust pathogen have been introduced for biological control of yellow starthistle. Although two insects have become abundant and widespread, there appears to be a need for additional agents to effectively control the weed. Foreign exploration was conducted in Europe as far east as Turkey and southern Russia, resulting in the discovery of six prospective arthropod biological control agents. Two of these have undergone extensive evaluation of host plant specificity and potential effectiveness. The rosette weevil, *Ceratapion basicorne* (Apionidae), develops in the upper root of rosettes and attains high levels of infestation in Turkey. A petition was favorably reviewed by USDA-APHIS Technical Advisory Group (TAG) in 2006, and we have formally requested permission to release it in California. The flea beetle, *Psylliodes chalcomera* (Chrysomelidae), has a biotype that is associated with yellow starthistle in Russia and Turkey that is distinct from populations associated with *Onopordum* and *Carduus* thistles. Molecular genetic methods are being developed to enable us to identify individuals. The mite, *Aceria solstitialis* (Eriophyidae), is currently being evaluated in Bulgaria. Preliminary life history and host specificity studies have been conducted on *Larinus filiformis* (Curculionidae), which is the most common seedhead insect in eastern Turkey, and the lace bug *Tingis grisea* (Tingidae). Rosette-boring fly, *Botanophila turcica* (Anthomyiidae), found in Greece has not been evaluated.

77. SIZE-SPECIFIC PREDATION RATES OF THE BEAUTIFUL HAWAIIAN DAMSELFLY ON THE SOUTHERN HOUSE MOSQUITO UNDER THREE DIFFERENT TEMPERATURES

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Larvae of the endemic Beautiful Hawaiian damselfly, *Megalagrion calliphya*, prey upon microcrustaceans and a variety of aquatic Diptera, including the larvae of the Southern House Mosquito (*Culex quinquefasciatus*). Even very small damselfly larvae have been observed to feed upon mosquito larvae, but the relationship of damselfly size to diet is unknown. Both damselflies and mosquitoes occur over a wide altitudinal range with corresponding changes in temperature. In order to better understand the predator-prey interactions between damselflies and mosquitoes, we observed predation among three damselfly size classes under three different constant temperatures (15, 22, and 28°C). Generally, higher proportions of damselfly larvae exhausted prey supply at 28°C compared to those at lower temperatures. Sixty percent of large damselfly larvae at 15°C and 22°C, and 90% of those at 28°C consumed all available prey. Of the remaining damselfly larvae (n = 162), medium sized larvae at 22°C consumed 91.4% of mosquito larvae offered on a daily basis. Those larvae ate more mosquitoes than the large-sized damselfly larvae at 22°C (88.5%), and their medium sized counterparts at 28°C (89%). Damselfly larvae of all sizes ate significantly fewer mosquitoes at 15°C, compared to those at 22 and 28°C. These data provide evidence that the predation rate of damselfly larvae on mosquitoes is affected by developmental size of the damselflies and water temperature. Damselflies of all size classes exhibited a higher feeding rate on mosquitoes in warmer waters and might be expected to have a larger effect on mosquito populations at lower elevations.

78. DIFFERENTIAL PREDATION OF STINK BUG EGGS BY THE RED IMPORTED FIRE ANT

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Stink bugs are important crop pests throughout the world. In the southeastern U.S. a complex of stink bugs attacks a variety of crops, including cotton, soybean, and tree fruits. This complex includes the brown stink bug, *Euschistus servus*; red-shouldered stink bug, *Thyanta custator*; southern green stink bug, *Nezara viridula*; and green stink bug, *Acrosternum hilare*. A field study indicated that insects with chewing mouthparts were important egg predators of this stink bug complex, and that egg predation rates varied between stink bug species. The red imported fire ant, *Solenopsis invicta*, is an introduced species that co-inhabits agroecosystems with stink bugs and is a voracious predator of many arthropod species. Therefore, subsequent laboratory studies were conducted to characterize stink bug egg predation by the red imported fire ant. Laboratory studies revealed differential predation on stink bug eggs; *E. servus* and *T. custator* suffered nearly 100% mortality, while predation of *N. viridula* and *A. hilare* eggs ranged from ca. 35-85%. The roles of physical factors (e.g., egg hardness and size) and chemical factors (e.g., repellence) in differential predation of stink bug eggs will be discussed.

79. PROPOSED PROTOCOL FOR TESTING THE ELEMENTAL DEFENSE HYPOTHESIS

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In 1992, a new strategy of plant defense was proposed and named the elemental defense hypothesis (EDH). This novel strategy suggested that some plants (termed hyperaccumulators) sequester exceptionally high concentrations of metals as a defense against herbivores. This hypothesis was subsequently extended to include plants that accumulated more modest amounts of trace elements. As of 2008, there are many papers that purport to have proven (or disproved) the elemental defense hypothesis. However, there is a lack of consistency among these empirical studies as to how to test for validity of the EDH. This has lead to considerable confusion. Here we propose a set of three falsifiable null hypotheses that must be rejected in order to verify that the presence of metals in plants is providing a defense against insects.

80. KEYNOTE: A NOVEL PLANT EXTRACT BASED PRODUCT FOR PEST MANAGEMENT

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Few plant species have been studied in detail for their phytochemical properties. However, with advances in isolation and identification techniques the opportunity for the discovery of novel plant compounds has improved. One area that has benefited from this development is that of biopesticides used either directly or synergistically with existing pesticides. These advances helped lead to the development of an essential oil biopesticide from the plant *Chenopodium ambrosioides* var. *ambrosioides* (QRD 400). The term "essential" indicates the compound is the fragrance essence of the plant, not the more common grammatical usage of indispensable. This plant extract biopesticide represents a new acaricide and insecticide class. Further isolation and bioassays led to the identification of specific, active materials leading to the development of KEYNOTE (QRD 416) – a plant extract based biopesticide. KEYNOTE has significant activity on an array of soft bodied insects such as thrips, aphids and whiteflies. Its mite activity has been well-defined on web-spinning mites (*Tetranychus* spp.) and some in the genus *Panonychus*. Its activity on other families of insects is being pursued. It is currently being field developed for use in a variety of vegetable, row and tree & vine crops.

81. IMPLEMENTING CODLING MOTH MATING DISRUPTION IN PEAR ORCHARDS USING PHEROMONE PUFFERS

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In 2007, pheromone puffers were used to disrupt mating of codling moth, Cydia pomonella, (L.) in approx. 1000 ac. of pear orchards in southern Oregon. One grower used Suterra Checkmate CM Puffers at a density of 0.9/acre on over 900 acres of Comice pear. Maps were generated of the puffer locations using PDA's with HGIS and ArcView GIS programs. Codling moth activity was monitored using Trece Combo and Suterra Biolure (10X) baited traps. Damage was evaluated with a series of fruit checks in the field and with packinghouse cull analysis. Data from puffer plots were compared to data from 1640 acres of grower standard mating disruption blocks using hand-applied pheromone dispensers at 200/acre (Checkmate CM XL-1000 or Disrupt CM). Results indicate that puffers were as effective as hand-applied dispensers in preventing trap catch and damage, and labor costs to deploy the pheromone puffers were approx. 2/3 less than the hand-applied dispensers. In most cases supplemental controls were applied to ensure control of codling moth and damage from codling moth in all blocks was negligible. Implementation of pheromone puffers for codling moth mating disruption allowed pear growers to limit supplemental pesticide treatments and address impending labor shortages.

82. ATTRACTION OF MALE SUMMERFORM PEAR PSYLLA TO VOLATILES FROM FEMALE

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Pear psylla, *Cacopsylla pyricola* (Förster) (Hemiptera: Psyllidae), is a pest of pears throughout North America and western Europe. Previous studies in our laboratory showed that males of the overwintering form (winterform morphotype) were attracted to volatiles from pear shoots infested with post-diapause females. The current study shows that males of the summer morphotype also are attracted to volatiles from female-infested host material. Older females (8-10 d in age) were significantly more attractive to males than younger (2-5 d in age) females. Both virgin and mated females attracted males. We show that volatiles from female summerforms attracted males even in the absence of host plant material, and that both living and freshly killed females were attractive. Our results support the hypothesis that female *C. pyricola* emit a volatile sex attractant, and have helped to further define the life history conditions in female pear psylla that lead to male attraction.

83. HYMENOPTEROUS PARASITOIDS ASSOCIATED WITH INSECTARY PLANTS ON THE CENTRAL COAST OF CALIFORNIA

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Research was carried out in the Salinas Valley on the Central Coast of California to determine if certain annual flowering plants, or "insectary plants," are associated with important parasitoids of caterpillars, aphids, and leafminers that attack vegetables. Vacuum samples were taken from six insectary plants grown in both conventional and organic production settings. The plants were sweet alyssum (*Lobularia maritima* (L.) Desv.), 'Dukati' dill (*Anethum graveolens* L.), 'Florentine' fennel (*Foeniculum vulgare* Mill.), baby's breath (*Gypsophila elegans* M. Bieb), 'Santo' coriander (*Coriandrum sativum* L.), and 'Dhani-ya' coriander. Plants were grown in single stands at three sites, and in a mixture that contained all varieties except alyssum at two sites. Seven types of leafminer parasitoids were collected from insectary plants in 2007. *Diglyphus* spp. was the most numerous leafminer parasitoid and *Halticoptera* spp. was the next most common. Both were found in each type of insectary plant. Leafminer parasitoids *Hemiptarsenus* spp. and *Chorebus* spp. were collected from dill and baby's breath. *Chrysocharis* spp. and *Alysia* spp. were collected from baby's breath. Baby's breath had the highest diversity of leafminer parasitoids, with six out the seven total species found. *Cyrtogaster* spp., parasitoids of Diptera pupae, were collected only from alyssum. Aphidiinae (aphid

parasitoids) were collected in all insectary plants sampled. *Pachyneuron aphidis*, an aphid parasitoid, was collected in dill, baby's breath, and the mixed insectary. *Copidosoma* spp., a parasitoid of Lepidoptera, was found in all of the insectaries. Microgastrinae and *Pteromalus* spp., parasitoids of Lepidoptera, were found in all insectary plants except dill. *Pteromlaus puparum* is a pupal parasitoid of *Pieris rapae*. *Conomorium* spp., a parasitoid of Lepidoptera, was collected from cilantro, dill, and the mixed insectary. *Goniozus cellularis*, a parasitoid of Lepidoptera, was collected from cilantro and baby's breath. *Conura* spp., a parasitoid of Lepidoptera, was collected from alyssum. Pests collected include *Lygus* spp. and *Diabrotica undecimpunctata*.

84. INSECTARY PLANTS FOR PEST CONTROL IN SPRUCE NURSERY YARDS

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Insectary plants have been widely used in agricultural systems for providing resources to natural enemies. In commercial nurseries in Oregon, aphids can be a challenge to manage on some woody and herbaceous plant stock. In 2006, we monitored the impact of insectary plants on the abundance of predators and pests in a commercial spruce 'can yard' in Yamhill County, OR. Spruce plots were surrounded by potted alyssum plants, coriander, or no insectary plants (control). Treatments were replicated in five blocks. Sampling was conducted 34 times from March 24 to December 8 by visually inspecting 10 or 5 spruce trees per plot. The number of ladybugs, lacewings, parasitized aphids, lygus bugs, cucumber beetles, and total predators/pests were not significantly different among coriander, alyssum, and control treatments. Also, the percent of spruce trees with/without aphids were similar among treatments. However, the presence of syrphid eggs and larvae was significantly higher in coriander than control plots, and intermediate in alyssum plots. Aphids were a persistent problem from May to November. Possible confounding factors such as the spacing of treatments, quantity of insectary plants, sampling limitations are considered, and will be addressed in upcoming plans in 2008.

85. FLOWER- AND POLLEN- SPECIFICITY OF SHRUB-VISITING BEES IN THE CALIFORNIA CHAPARRAL

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The California chaparral has been described to have a high representation of plant specialist bees, and this study was conducted to establish if pollen specialization is as widespread as might be suggested by flower visitation data. Bees were collected on spring-flowering shrubs in Napa County for two years. For each species 1) flower specificity, based on visitation data of males and females, and 2) pollen specificity, based on female pollen-load composition, was established.

A total of 73 bee species, representing six families, were collected on 11 shrub species. The number of bee species per shrub ranged from 3 (*Dendromecon rigida*) to 26 (*Ceanothus parryi*). Close to half of all bee species visited only a single shrub species; however, slightly over half were only occasional visitors (infrequently collected), <10% were only regular visitors, and the rest were both regular and occasional visitors on different shrubs. Andrenidae bees visited the lowest number of shrubs, Apidae the highest. Pollen-load data from 26 bee species show a wide range of purity (= pollen constancy). Andrenidae (9 spp) displayed the highest constancy: >75% bees carried pure loads (all *Ceanothus*). Pollen loads indicate that many bee species (especially Apidae and Megachilidae) were not as specialized in pollen foraging as suggested by flower visitation. Pollen constancy by individual bees was common, but pollen specialization at the species level was rare. Furthermore, shrub species that shared regular-visitor bee species tended to have distinct peak blooms periods, suggesting that bees were mainly opportunistic in their foraging.

86. INTEGRATED MANAGEMENT OF THE HONEY BEE PARASITE *VARROA DESTRUCTOR* IN WESTERN WASHINGTON STATE, USA

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The exoparasitic mite *Varroa destructor* (Anderson and Trueman) continues to threaten domestic honey bee *Apis mellifera* (L.) stocks and thus negatively impacts both the honey and pollination industries. The development of resistance to acaricidal treatments has diminished the efficacy of control compounds, such as coumaphos and fluvalinate. Using an integrated pest management approach, we will test the efficacy of a bio-rational pesticide, formic acid, as a natural replacement for failing synthetic acaricides. We will also examine the role of application timing and pest population monitoring in treatment efficacy. Economic threshold levels of *Varroa* mite populations will be estimated for colonies in western Washington State using measured and seasonally varying attributes, such as brood area, population size and mite levels among a set of hives that have received differing treatment regimens. Sixty colonies were established in Puyallup, WA in July 2007 in five treatment groups and will be monitored through May 2008.

87. POLLINATOR BEE PESTICIDE SAFETY TRIALS ON ALFALFA SEED, 2006-2007

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The alkali bee, *Nomia melanderi*, and the alfalfa leafcutter bee, *Megachile rotundata*, are significant pollinators of alfalfa seed in Washington State. It is imperative that we know whether the pesticides used on alfalfa seed to control Lygus bug, aphids, and mites are toxic to these

pollinating bees. Preliminary trials were conducted in 2005 with fenpyroximate and bifenthrin (very toxic to bees) to develop the experimental protocol. Registered and candidate insecticides and miticides were tested against bees in 2006 and 2007. Products were applied at either maximum label rate or maximum recommended rate for control of certain alfalfa pests over 0.01-acre alfalfa plots. Alfalfa samples were collected at one and eight hours after treatment for the bee bioassays, with treatment and age of residue replicated four times. In 2007, leafcutter bee pupae were emerged in specially designed boxes; this method allowed for an ample supply of similarly young-aged, healthy bees for testing. Leafcutter bees were exposed to the aged residues for one to 24 hours at which time mortality was scored. In 2007, three newly registered chemicals were tested against field-collected alkali bees as well. In 2006, after one-hour of exposure, all pesticide treatments except bifenthrin resulted in less than 25% mortality. In 2007, when the leafcutter bees were exposed to one-hour residues for 24 hours, six out of 12 compounds resulted in less than 25% mortality: bifenazate, acetamiprid, flonicamid, imidacloprid, novaluron, and etoxazole. When bees were exposed to eight-hour residues for 24 hours, all the pesticide treatments but thiamethoxam, spiromesifen, and spinosad caused less than 25% mortality to bees. For alkali bees, after a one hour exposure to eight-hour residues, very low mortalities were recorded for acetamiprid, flonicamid, and novaluron.

88. A SURVEY OF PREDACIOUS MITES (ACARI: PHYTOSEIIDAE) IN NORTH COAST CALIFORNIA VINEYARDS

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Native and introduced predacious mites in the family Phytoseiidae are important biological control agents of spider mites and thrips in California vineyards. The types of insecticides used in vineyards have dramatically changed in the last ten years from organophosphates and carbamates to a number of different chemical classes, many of which are more selective. This might have impacted phytoseiids diversity and abundance. Exotic pest mites and thrips have become established many times throughout California history and continue to be introduced. A better understanding of the predacious mites present in vineyards may aid in managing new pests. We undertook a three-year survey of phytoseiids in 21 vineyards in four North Coast counties of the winegrape growing region of California. Each site was monitored monthly from May to November. The most abundant predacious mite found was *Typhlodromus pyri* followed by *Euseilus quezali* and *Galendromus occidentalis*. On average two species of phytoseiids were found per site per date with a range of 1 to 7 species. Approximately the same phytoseiid species composition was found at each site through the season and through the three year surveyed. A total of 15 species were collected from grapevines. Two species had never been reported from California: *Amblyseius andersoni* and *Graminaseius graminus*.

89. DETERMINING THE IMPACT OF OFTEN USED PESTICIDES ON NATURAL ENEMIES IN NORTHWEST OREGON VINEYARDS

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It is believed that Short Shoot Syndrome (SSS) is directly caused by rust mites *Calepitrimerus vitis* (Nalepa) feeding on rapidly developing buds at the onset of early season growth. SSS often result in heavy crop losses in Oregon vineyards. The heavy reliance on sulfur sprays may be one of the contributing factors for mite population explosions as these sprays are detrimental to important predatory mites such as *Typhlodromus pyri.* Preserving arthropod predator abundance and diversity in grape vineyards may reduce pest populations such as mites, thrips, and leafhoppers; and subsequent losses in yield. In order to determine the effects of often used compounds field trials were done in two Northwest Oregon vineyards during 2007. In one vineyard high predatory mite numbers were found in plots where no sulfur, early sulfur and rotated sulfur treatments were applied. Lower predatory mite numbers were found in plots where repeated applications of sulfur were made. In this vineyard it appeared as if high pheitoseid mite populations provided some control over pest mite populations. Data was however not consistent and for this reason need to be supported by laboratory bioassays. The details of planned supporting laboratory non-target bioassays are therefore discussed.

90. LARGE PANEL TRAP PROVIDES HIGH EFFICIENCY AND LARGE CAPACITY FOR MOTH FIELD RESEARCH

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Trap saturation, the decrease in traps' efficiency due to accumulation of trapped insects and debris, is a problem in all insect traps but especially in sticky traps. During field tests to trap navel orangeworm males (ca. 1.5 cm wing span) delta and wing traps whose liners (sticky surface ca. 465 cm^2) were not replaced captured progressively fewer moths after ca. 50-60 moths were captured, whereas our panel traps (sticky surface ca. 14,000 cm^2) continued to catch in moths in high numbers. Whether nightly moth trap catch was low or high, the large sticky traps performed well with moths distributed over the entire surface of the traps from the onset of a test, and these large traps captured up to 10-fold more moths per night than commercial traps whose trapping surface was changed nightly. The large traps' higher catch numbers per night imply that these traps have a larger sampling radius than wing and delta traps. This large sticky trap can be readily assembled in the laboratory from common building materials. Trap color also influences trap catch of navel orangeworm males and females and should be examined further.

91. PERFORMANCE OF METHYL EUGENOL AND CUE-LURE DETECTION TRAPS WITH AND WITHOUT INSECTICIDES, WITH A REDUCED RISK INSECTICIDE, AND WITH A FARMA TECH SOLID LURE AND INSECTICIDE DISPENSER FOR CAPTURES OF ORIENTAL AND MELON FRUIT FLIES (DIPTERA: TEPHRITIDAE)

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Methyl eugenol (ME) and cue-lure (C-L) detection traps for fruit flies on the U.S. mainland were tested with and without insecticides under Hawaiian weather conditions against *Bactrocera dorsalis* (Hendel), oriental fruit fly, and *B. cucurbitae* (Coquillett), melon fly, respectively. In comparative tests, standard Jackson Traps with naled outperformed traps without an insecticide. Addition of a reduced risk insecticide, spinosad, did not increase trap capture significantly. Captures by the Hawaii fruit fly Area-Wide Pest Management (AWPM) Trap with insecticide strips compared favorably to those for the Jackson trap with liquid naled. In subsequent tests with solid Farma Tech wafers containing ME or C-L and DDVP, Jackson and AWPM Traps captures were equal to or better than those for a Jackson Trap with a liquid insecticide and lure mixture (Jackson Trap with naled) currently used for detection of ME and C-L responding fruit flies in Florida. From a worker safety and convenience standpoint, Farma Tech ME and C-L wafers with DDVP would be more convenient and safer to handle than current liquid insecticide formulations used for detection programs.

92. CASPASE 3 ISOLATION AND ACTIVITY WITHIN STERILE MALE *CERATITIS CAPITATA* WEIDEMANN

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Sterile male medflies sustain radiation damage to nontarget tissue, particularly gut tissue. This damage may result in fitness costs that affect their performance in Preventative Release Programs. A diet containing beneficial gut symbionts has been shown to improve the gut of sterile males. Notably, the amount of apoptosis in midgut epithelial tissue appears to be reduced for flies that fed on the bacterial diet. To further investigate and explain this phenomenon, a key enzyme of the apoptotic cascade was isolated from both sterile and nonirradiated medflies and compared. This is the first report of the isolation of Caspase 3 from medflies and a first step toward understanding the role bacteria play in medfly tissue repair.

93. AUDITING MICROBIAL DIVERSITY WITHIN MOSQUITOES: A PRELUDE TO USING SYMBIONTS TO COMBAT ANIMAL PATHOGENS

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Mosquitoes are one of the most deadly vectors known to humankind. These insects transmit a broad range of pathogens to more than 70 million people annually, underscoring the need to develop better strategies in managing mosquito borne illnesses. We are examining alternative methods to interrupt pathogen transmission, including paratransgenesis and broader types of symbiotic control. Microbes within the mosquito alimentary canal are good targets to deliver anti-pathogen molecules since they exist in close association with pathogen propagation and transmission.

Implementation of any symbiotic control program and a complete understanding of pathogen propagation and transmission necessitate a complete audit of the microbial biodiversity within mosquitoes. We have begun characterizing the microbiota within the midgut of several different mosquito species. Using standard culture techniques and sequencing of the prokaryote 16S rDNA gene, we have isolated and identified a variety of different microbial species found within the mosquito midgut. We have also identified several viable but nonculturable bacteria through DNA cloning and sequencing. Microbes that are amenable to culture in the laboratory are being characterized and evaluated for use in paratransgenic and symbiotic control approaches toward management of mosquito borne diseases.

94. MANAGEMENT OF COTTON APHIDS, *APHIS GOSSYPII*, WITH INSECTICIDES IN SAN JOAQUIN VALLEY COTTON

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Several insecticides were evaluated over a three-year period for control of cotton aphids (*Aphis gossypii*) in San Joaquin Valley cotton. The studies were conducted in Tulare, Kern, and Fresno counties, California during the mid-season period, i.e., July to mid-August, and during the late-season period, i.e., following boll opening. Prior to the mid-season insecticide applications, populations were generally in the 15 to 40 aphids per leaf range with the exception being the study in 2006 in Kern Co. where populations were 150 aphids per leaf. Late-season populations averaged about 10 aphids per leaf which is near the treatment threshold level for this part of the production season. Overall, during the mid-season period, neonicotinoid products, Assail (*acetamiprid*), Provado (*imidacloprid*), and Centric (*thiamethoxam*), provided good to excellent aphid control. Several formulations of Assail were evaluated and generally provided equivalent control. Organophosphate products, Dibrom (*naled*) and Lorsban 4E (*chlorpyrifos*) were also effective. Other formulations of chlorpyrifos were also tested and were less effective. These are under consideration due to the VOC concerns from use of EC formulations in the SJV. Carbine

(*flonicamid*), a product from a new class of chemistry which was registered for use in 2007, was also a very effective treatment. On late-season aphids, these same products were generally again the most effective, but overall control of aphids during this period was more challenging and erratic than during the mid-season.

95. CONCENTRATION OF IMIDACLOPRID IN MELONS AND LETTUCE: ARE THERE DIFFERENCES AMONG COMMERCIAL PRODUCTS?

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The neonicotinoid insecticide imidacloprid was first registered for commercial crops in Arizona and California in 1993 and 1994, respectively. It is used intensively in the desert agricultural valleys on all leafy vegetable crops and various melon crops including cantaloupes, honeydews and watermelon. Systemic, soil-applied treatments of imidacloprid have been particularly effective at controlling *Bemisia tabaci* populations by providing long residual activity that significantly delays population growth. Beginning in 2006, commercialization of imidacloprid was no longer protected by patent and a host of generic imidacloprid products came to market. As part of an ongoing project to evaluate activity profiles of imidacloprid and other neonicotinoid insecticides in crops, leaf samples are collected and returned to the laboratory for extracting imidacloprid to determine concentration in leaf tissue. A commercial ELISA kit (EP 006 Envirologix, Portland, ME) is then used to quantify imidacloprid concentrations at a limit of detection of 0.07 ppb in under two hours for 90 samples. Significant variation in concentration of imidacloprid has been detected among five different commercial products in spring cantaloupes and fall lettuce. Additional field trials are planned that will investigate whether unique field and soil conditions contributed to the differences or if formulation differences affect uptake and distribution of imidacloprid in certain crops.

96. WITHIN-FIELD MOVEMENT OF BILLBUGS IN UTAH TURFGRASS

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Billbugs (Coleoptera: Curculionidae) are some of the most common turfgrass pests in northern Utah. The biology and life history of billbugs is not well understood, especially for the Denver billbug (*Sphenophorous cicatristriatus*). A Kentucky bluegrass, *Poa pratensis*, field was sampled in 2007. Billbugs were sampled using a 33-quadrant grid. From within each quadrant, one soil core was taken at random and completely dissected for all billbug life stages. Sampling started 16 May and ended 13 August. The average number of larvae and adults per square-foot was estimated. On 18 May, the turf was treated with imidacloprid to reduce billbug feeding damage. Spatial and temporal data were estimated for each collection data. Data were interpolated with inverse distance weighting using a geographic information system, ArcMap. In general, billbug

larval densities were low, but were uniformly distributed throughout the site. Larvae rebounded from the insecticide and reached a peak density on 10 July. Adult billbug densities also remained fairly constant throughout the summer. The insecticide application did not appear to be effective in reducing billbug larvae.

97. CHEMICAL CONTROL OF THE INVASIVE ERYTHRINA GALL WASP ON NATIVE AND LANDSCAPE ERYTHRINA TREES

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The erythrina gall wasp (EGW), *Quadrastichus erythrinae*, Kim (Hymenoptera: Eulophidae) is one of the most devastating invasive species introduced into the State of Hawaii. EGW host range includes *Erythrina sandwicensis*, a native and large component of dry land forest areas, as well as *Erythrina variegata,* abundant in landscapes. Our work focused on immediate control of this pest with safe and effective insecticides. Insecticides and application methods were selected based on criteria of efficacy, treatment longevity and non target impact. Imidacloprid applied systemically as a root drench or injected through trunks was effective against EGW. Root drenches were inconsistent and recommended only for containerized trees or those irrigated and naturally contained. Trunk injection systems were very efficacious but varied in response among injection systems. One of the most effective injection systems evaluated was the Arborjet system (arborjet.com); it performed consistently and allowed for the most volume of liquid to be injected into a trunk through the fewest locations. Imidacloprid was very persistent within the leaves and can provide season- or year-long control.

98. IMPACT OF DELEGATE™ WG INSECTICIDE ON TETRANYCHID AND PREDATORY MITES IN APPLES

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Delegate™ WG, a new spinosyn insecticide containing spinetoram, was recently granted registration by the USEPA for use in pome fruits. Assessments of tetranychid and predatory mite populations were made during codling moth field efficacy studies conducted in central Washington between 2004 and 2006. Results indicate that under worst-case conditions of six consecutive Delegate WG applications made through the entire season, a reduction in the seasonal incidence of the western predatory mite, *Typhlodromus occidentalis* Nesbitt may occur. However, corresponding increases in the seasonal incidence of the two major tetranychid mite species, twospotted spider mite, *Tetranychus urticae* Koch, and European red mite, *Panonychus ulmi* (Koch), were not observed. Seasonal incidence of *Zetzallia*

mali (Ewing), another predatory mite species present in apple orchards, were not affected by Delegate WG applications and may have offset any decrease in predation by the western predatory mite. Based on the response of the predatory mite complex that was observed in these studies and the product label requirement of no more than three consecutive applications, the commercial use of Delegate WG to control codling moth is not expected to cause outbreaks of twospotted spider mite and European red mite.

99. KEYNOTE: FIELD PERORMANCE OF A NOVEL, CONTACT INSECTICIDE BASED ON AN EXRTACT OF CHENOPODIUM AMBROSIOIDES

Paul Walgenbach, and Brett Highland

AgraQuest, Inc. 1530 Drew Avenue. Davis, CA 95616

KEYNOTE™ is a novel, contact insecticide/acaricide based on a plant extract. Advances in isolation and identification techniques have lead to the opportunity for the discovery of novel plant compounds that can be developed as biopesticides. These compounds can be used either individually or in synergistic combinations. KEYNOTE Insecticide/Acaricide is one result from these efforts. Keynote is based the plant extracts from *Chenopodium ambrosioides* var. *ambrosioides*, a plant with Central American origins. The extract is based on the plant's essential oils; "essential" indicating the compounds are the fragrance essence of the plant, not the more common grammatical usage of indispensable. Field development efforts have focused on the control of soft bodied insects in vegetable crops. This presentation will discuss results on trials evaluating performance primarily on such soft-bodied insects as thrips, aphids, whiteflies and mites. The initial target crops are onions, peppers, cucurbits and tomatoes. Development plans beyond the core crop/pest complexes and registration timelines will also be discussed.

100. MODELING EVOLUTION OF CODLING MOTH RESISTANCE TO A VIRUS

David W. Onstad

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In Europe, the codling moth, Cydia pomonella, has recently evolved resistance to a viral insecticide consisting of CpGV. A model was developed to simulate the population dynamics and genetics of the insect in treated orchards. The analysis investigated various ways in which evolution may have occurred and the possible strategies for resistance management.

101. IMPACT OF ARGENTINE ANT (*LINEPITHEMA HUMILE*) FORAGING ON DEVELOPING MEALYBUG PARASITOIDS IN VINEYARDS

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The Argentine ant, *Linepithema humile* (Mayr), disrupts biological control of hemipteran pests in California's agricultural ecosystems by decreasing natural enemy effectiveness and altering the parasitoid species complex. Although well documented, the nature of the disruptive effect remains unclear. Ants may interfere with oviposition behavior of the adult parasitoids or disrupt parasitoid development. Here we report on the impact of ant tending on the pupal stage (mummy) of the mealybug parasitoids, *Anagyrus pseudococci* (Girault) and *Coccidoxenoides perminutus* Girault. Mealybug mummies grouped by treatment (ant-tended or ant-excluded) were observed at regular intervals over a 50 hour period. At all sampling times, there were significantly fewer *A. pseudococci* mummies remaining on the ant-tended vines as compared to the ant-excluded vines. Although there were significantly fewer *C. perminutus* mummies on ant-tended vines during the first 4 hours, there was no significant difference between treatments at 8, 26, or 50 hours. Differences between species may be attributed to the attractiveness of one or the other as a food source, and may be explained by the larger size of the *A. pseudococci* mummy. This phenomenon warrants further exploration, and will be addressed in subsequent trials. This study has broader implications for the management of Argentine ants and in understanding the complexities of the ant-hemipteran mutualism.

102. PLATINUM AND ACTARA FOR THE CONTROL OF KEY PESTS IN GRAPES

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Platinum and Actara are insecticides that contain thiamethoxam and have recently received federal registration for the use in grapes. Platinum is labeled for soil applications and Actara is labeled for foliar applications. Pests controlled by Platinum applied at 0.125 to 0.266 lb ai/A includes Japanese beetle (*Popillia japonica*), leafhopper spp. (*Erythroneura* sp. or *Empoasca* sp.), grape mealybug (*Pseudococcus maritimus*), vine mealybug (*Planococcus ficus*), grape Phylloxera (*Phylloxera* sp.), and glassy winged sharpshooter (*Homalodisca coagulata*). Actara applied at 0.023 to 0.055 lb ai/A controls all of the previously mentioned pests except for grape Phylloxera. The efficacy of both thiamethoxam products on grape pests is equal to or superior than comparable competitive products.

103. SEASONALITY DRIVES PIERCE'S DISEASE EPIDEMIOLOGY IN CALIFORNIA VINEYARDS

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The pathogenic bacterium *Xylella fastidiosa* (*Xf*) is vectored to grapevines by several species of xylem-feeding leafhoppers, causing Pierce's disease (PD). The establishment of one of these vectors in California, the glassy-winged sharpshooter (GWSS; *Homalodisca coagulata*), coincided with devastating PD outbreaks. The most common explanation for why GWSS precipitates PD outbreaks is that, unlike native sharpshooters, GWSS encourages vine-to-vine spread. However, many of these secondary infections do not persist over winter - especially those occurring later in the season. Moreover, vector acquisition rates of *Xylella* may vary seasonally. The implications of these seasonal factors for PD prevalence are not well understood. We used a vectored SI disease simulation model to clarify the consequences of seasonal vine recovery and vector acquisition on PD epidemiology. The results suggest that low acquisition rates early in the season and high recovery rates of late season infections can temper disease outbreaks. However, high rates of pathogen retention (within the vector) over winter and, especially, high vector densities rapidly swamp out the ameliorating effects of seasonality. These results are relevant for evaluating the effectiveness management techniques, such as roguing, and for pinpointing the windows of vulnerability to chronic secondary disease spread.

104. TRANSMISSION MECHANISM OF *XYLELLA FASTIDIOSA* BY SHARPSHOOTER VECTORS AND A MODEL FOR QUANTIFYING VECTOR EFFICIENCY

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The exact mechanism of transmission (acquisition and inoculation) of *Xylella fastidiosa* (*Xf*) by sharpshooter vectors such as the glassy-winged sharpshooter, *Homalodisca vitripennis*, has been unknown. This presentation will summarize five years of work to identify the transmission mechanism in terms of fluid flow into and out of the vector's alimentary canal, especially the area termed the precibarium. It will also present a model of four critical steps to assure success in the transmission process. The first step is whether *Xf* bacteria are acquired into a clean precibarium or one already occupied by competing microbes. The second step is whether bacteria colonize a specific location within the precibarium, from which they are dislodged during feeding. The third step is performance of a specialized inoculation behavior that consists of salivation, ingestion of mixed saliva and plant fluid, followed by two different types of egestion, each from a different area of the precibarium. Thus, the mechanism of inoculation is a combination of salivation and egestion. These behaviors have been correlated with electrical

penetration graph (EPG) waveforms, used to measure durations and how often they are performed. The fourth step is whether inoculation behaviors are performed in a xylem cell. Each of these steps can be quantified to determine an overall percent transmission efficiency score. Future work will use this quantitative model to compare transmission efficiencies among between the virulent Temecula strain vs. EB92-1, the benign biocontrol strain of Hopkins.

105. EPIDEMIOLOGY OF XYLELLAE DISEASES IN THE SAN JOAQUIN VALLEY OF CALIFORNIA: THE ROLE OF ALFALFA

Mark Sisterson[1], Kent Daane[2], Shyamala Thammiraju[2], and Russell Groves[3]
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Pierce's disease of grape and almond leaf scorch disease are both caused by various stains of the bacterial pathogen *Xylella fastidiosa.* The pathogen is vectored by xylem feeding insects. Within the San Joaquin Valley of California, the green sharpshooter (*Draeculacephala Minerva*) is one of the most important vectors. This insect is often found in large numbers in cultivated alfalfa fields and alfalfa is a known host of *X. fastidiosa*. Studies were initiated to assess the importance of alfalfa in the epidemiology of xylellae diseases in the San Joaquin Valley of California. Specifically, we: 1) assessed the suitability of alfalfa to serve as a host of *X. fastidiosa,* 2) estimated the incidence of *X. fastidosa* in alfalfa fields, and 3) monitored green sharpshooter populations in alfalfa fields. Results from these studies will be reported.

106. ASSESSING POST-WINTER THREAT OF GLASSY-WINGED SHARPSHOOTER POPULATIONS IN CALIFORNIA

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The glassy-winged sharpshooter (GWSS), *Homalodisca vitripennis* Germar, vectors *Xylella fastidiosa* Wells et al., the causal agent of Pierce's disease and other scorch-like diseases. Winter conditions appear to be important determinants of GWSS distribution in the state. Previous work showed that feeding is curtailed at temperatures below 10° C, and that adult death occurs within three weeks at temperatures below this threshold in the presence of hosts. To develop local risk maps for post-winter establishment of GWSS populations throughout the state, we applied the concept of cooling degree-days (CDD) to estimate the impact of cool temperatures on GWSS survival. Adult sharpshooters were subjected to fluctuating daily winter temperatures in

environmental chambers simulating conditions in nine sites around California. Potted citrus and acacia were provided as hosts, and GWSS survival was monitored weekly for up to five months. The relationship between cumulative CDD and percentage survival was calculated, and will be integrated with historical information on local temperature variations to define the level of risk of GWSS establishment and allow more focused monitoring and management efforts.

107. MEALYBUG PHEROMONES: CURIOUS CHEMISTRY AND PRACTICAL APPLICATIONS

Jocelyn Millar[1], Kent Daane[2], Steve McElfresh[1], Jardel Moreira[1], Bruno Figadere[1], Walt Bentley[3]
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Vine, obscure, longtailed, and grape mealybugs constitute four of the most important and widespread mealybug pests of vineyards in California and many other areas of the world. They are also known to infest a wide variety of other crop and ornamental plants. Over the past several years, we have identified and synthesized the sex pheromones of these four important pest species. This paper will summarize the methods used in the collection and identification of the pheromones, and the very unusual chemistry of these compounds. The biological activity and possible practical applications of these pheromones will be briefly discussed, along with various physiological and environmental factors that may affect trap catches.

109. INTEGRATED PEST MANAGEMENT OF VINE MEALYBUG, *PLANOCCOCUS FICUS* (SIGNORETE) IN THREE GRAPE PRODUCTION SYSTEMS

Walt Bentley

Kearney Agricultural Research and Extension Center, 9240 South Riverbend Avenue, Parlier, CA 93277

Vine mealybug management in raisin, wine, and table grapes is primarily achieved with insecticides. However, the intensity of the insecticide use and the integration of cultural, physical, and biological controls are quite dependent upon the grape production system. Export of table grapes exacerbates the need for insecticides. This is not true of raisin and wine grapes. Net return per acre for raisin, wine and table grapes grown in the San Joaquin Valley is $645, $1164, and $3042 respectively. Per acre profit influences what level of IPM a farmer will utilize. More importantly are export requirements for table grape farmers, even though they are much more able to afford a truly integrated program that includes monitoring, they are less inclined to do so. This is primarily because almost 40% of the crop is exported which accounts for nearly 70% of gross table grape revenue. Restrictions on movement of pests such as vine mealybug and black widow spider impose a zero threshold for these pests.

110. TOLERANCE OF LEAF REMOVAL AND ROOT DAMAGE: MECHANISMS AND AGRICULTURAL APPLICATIONS

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In this talk, I will begin by discussing mechanisms of tolerance and then move to a specific application of tolerance in an agricultural system. I will address mechanisms of tolerance by reviewing published research on tolerance of leaf removal in pigweed *Amaranthus hybridus*, and in some other species. Research on *A. hybridus* shows how tolerance can be affected by variation in water availability and photosynthetic efficiency, with the latter arising from plants having genetically based resistance or susceptibility to the herbicide triazine. I will consider the effect of these physiological and environmental variables on the allocation of biomass to root versus vegetative tissue, and whether such affects on allocation in turn alter tolerance. For the second part of the talk, I will introduce an application of tolerance in a crop system using the case of variation in tolerance among corn varieties to root damage from the western corn rootworm *Diabrotica virgifera virgifera.* This research represents an effort to identify corn varieties in Eastern Europe that are more tolerant to feeding damage from *D. virgifera virgifera*, which is a recently introduced invasive species in the region.

111. UNDERSTANDING THE EFFECTS OF PLANT DOMESTICATION ON TRI-TROPHIC INTERACTIONS IN TWO CROPPING SYSTEMS

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Crop domestication has altered significantly the interactions between natural enemies and their associated herbivores by changes in plant phenotype, system attributes, or the interactions between system traits and plant phenotype. Two model systems using native herbivores and their native natural enemies have been disrupted inadvertently by development of physical refugia from parasitism for the herbivore. Strawberries with closely spaced achenes were shown to reduce the proportion of *Lygus* eggs available to the native egg parasitoid, *Anaphes iole*. The relative level of refugia is a function of fruit age and maturity.

In a series of studies in wild and agricultural sunflowers, parasitism of the sunflower moth, *Homoeosoma electellum*, has been significantly altered by the development of larger seeds which interfered with successful oviposition by the parasitoid *Dolichogenidea homoeosomae*. Early plantings of agricultural fields that were out of synch with populations of wild sunflowers avoided high infestation levels by the sunflower moth, *Homeosoma electellum*. However, plantings of agricultural fields later in the season experienced higher damage levels and lower parasitism levels compared to populations of sunflowers in wild habitats. Significant interactions

between nitrogen levels and plant growth exacerbated the differences in high nitrogen conditions, whereas differences between the 2 genotypes disappeared under low nitrogen levels found in wild habitats.

Parasitoid searching behavior was sub-optimal in agricultural settings in which multiple larvae are often found in sunflower heads. Parasitoids would typically oviposit into a single larva and proceed to leave the flower head despite the presence of other suitable hosts. In contrast, wild sunflower typically have 1 larva per flower head such that the parasitoid's searching behavior would be appropriate. Studies using 9 polymorphic microsatellite loci suggested high rates of gene flow between agricultural and wild habitats, thus possibly limiting the evolution of populations of parasitoids adapted to agricultural settings.

112. THE BIO-ECONOMIC OF PLANT – INSECT INTERACTIONS

Andrew Paul Gutierrez

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Adapted species in nature are assumed to have solved renewable resource management problems, and these relationships are examined using a physiologically based model of energy acquisition and allocation in a tritrophic system embedded in a bio-economic frame work. Analogies between the economies of humans and other species are used to develop a bio-economic objective function for individual utility of energy allocation. The objective function includes the physiologically based population dynamics models of the consumer and resource species in a food chain as dynamic constraints. The model applies to all trophic levels in a food chain including human harvesting of renewable resources.
Specifically, the analysis:
(1) Combines ecological and economic theory;
(2) Points out the importance of time frame in the two economies (evolutionary vs. market time);
(3) Examines the effects of expected uncertainty due to environmental hazards in defining energy acquisition and allocation strategies in r- and K-strategies.
(4) Evaluates the effects of changes in behavioral and physiological parameters and environmental degradation on the abundance of resource and consumer species.

Cotton will be used as a model system in this analysis.

113. COTTON COMPENSATION FOR LYGUS HERBIVORY? AN EXPERIMENTAL APPROACH

Peter C. Ellsworth

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Cotton is a dynamic plant equipped with sufficient redundant photosynthetic infrastructure to compensate for all sorts of injury. Crop models generally incorporate this known phenomenon. On average, cotton grown in Arizona achieves maximal yields at final fruit retentions of just 50-55% (of the 1st two position fruiting forms). This, too, suggests that cotton is rather tolerant to insect damage and fruit loss, especially fruit loss that occurs early in the season. Compensation for early damage in cotton caused by *Lygus hesperus* Knight (Hemiptera: Miridae) is a concept identified over three decades ago and spurred much controversy among researchers and producers of the day.

Over the last decade, we have conducted a series of studies to examine Lygus damage dynamics and yield responses in Arizona cotton. The result has been a much clearer definition of the role Lygus play in damaging cotton. There are levels that can readily be tolerated in cotton. Furthermore, there are perhaps even certain difficult to measure, low levels that contribute to

yield stimulation. These studies have identified guidelines for action thresholds that consider the activity and abundance of both adults and nymphs. Regression analyses showed maximal yield at 15 total *Lygus* with at least 1.7 nymphs per 100 sweeps. However, revenues were maximized over a wide range of economic conditions at 15 total *Lygus* with at least 5.2 nymphs per 100 sweeps. Extension guidelines were taught to growers and implemented in AZ and Mexico using action thresholds of 15 total *Lygus* with at least 4 nymphs per 100 sweeps ('15:4'). This level has effectively protected yields over a wide range of commercial conditions. As the plant senesces and fewer flowering/fruiting sites are produced, the need for and return on control investment diminishes. Termination rules for discontinuing *Lygus* chemical controls over twelve different production scenarios (2 planting dates x 2 irrigation termination timings x 3 different maturity groups) revealed an extremely dynamic relationship between yield/revenue and bug density. Generally, shorter season varieties benefit less from extended protection from *Lygus*. Longer season varieties appear to be especially vulnerable to *Lygus* damage and therefore more responsive to *Lygus* controls, despite their putative greater capacity for compensation.

114. COMPENSATION OF LYGUS-INDUCED FRUIT LOSS IN COTTON: EFFECT OF PLANT PHENOLOGICAL STAGE

Megha N. Parajulee

Cotton Entomology Program, Texas AgriLife Research and Extension Center, Lubbock, Texas

Cotton yield compensation to Lygus-induced fruit loss has been studied for the last seven years in the Texas High Plains. Historically, Lygus is not a serious economic pest of cotton in this region, but it has become an emerging issue in recent years. Also, the Texas High Plains is known to have the best early fruit retention as compared to other cottonbelt regions. Thus, an emerging question now is whether a high level of early fruit retention is necessary, given the cotton's ability to compensate. The objective of this study was to quantify the compensation ability of cotton to Lygus-induced fruit loss at two phenological stages: three weeks pre-flower and the first three weeks of flowering. Experiments were designed to achieve different levels of pre-flower square loss and the loss of fruiting structures during early flowering by augmenting natural populations of Lygus bugs with laboratory reared nymphs. Four treatments each were utilized for pre-flower and during-flower stages: 1) 3 bugs per plant augmented (3PP), 2) 1 bug per plant augmented (1PP), 3) naturally occurring background density or untreated control (UC), and 4) 0 bug achieved through insecticide spray applications (SC). Artificial infestations of Lygus bugs released at two different crop growth stages caused variable fruit loss. It is demonstrated that the plant could compensate pre-flower square loss slightly better (25-30%) than the early flower fruit loss (20-25%) when environmental conditions were favorable. If conditions were not favorable, 25-30% of the fruit will be shed physiologically so the insecticide intervention to save early squares may not be necessary. Therefore, it is important to consider plant compensation potential, input variables (fertility, moisture), and environmental stress while making insect management decisions. However, control costs and efforts to protect less than a 30% and 25% fruit shed during early squaring and during early flowering, respectively, may not be necessary in the Texas High Plains region.

115. COTTON COMPENSATION FOR *LYGUS* HERBIVORY: AN ECOINFORMATICS APPROACH

Jay A. Rosenheim

University of California, Davis, CA

Applied insect ecologists have traditionally relied upon experimentation to define the impact of herbivory on crop plants, and thence to establish economic injury levels and control recommendations. Experimentation allows researchers to infer causal relationships, and thus is a powerful tool for applied ecologists, and yet experimentation also has some limitations. Here I suggest that an ecoinformatics approach, which uses pre-existing data generated in a non-experimental setting, can be a useful complement to the traditional experimental approach. I illustrate the approach by studying the impact of *Lygus hesperus* herbivory on cotton yield. Data on *Lygus* densities and cotton yield were obtained from private pest control consultants and cotton growers, and analyzed to characterize the form of the plant compensation function. Strengths and weaknesses of the ecoinformatics approach, along with the initial results of the study, will be discussed.

116. MONITORING AND CONTROL OF INVASIVE ANT PESTS IN AGRICULTURAL SETTINGS

Les Greenberg, Kris Tollerup, John H. Klotz, and Michael K. Rust

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Red imported fire ants (*Solenopsis invicta*) are relatively new to California. Estimating their numbers can be done quickly using corn chips in small plastic cups. Using this monitoring technique we did a study of fire ant baits at a date palm grove in the Coachella Valley. We compared the efficacy of hydramethylnon baits to a new metaflumizone bait and found that the new bait gave better results over time. We have also done field trials with Argentine ants (*Linepithema humile*) in citrus groves using liquid baits in large bait stations. We tested products containing boric acid, imidacloprid, and methoprene. Reductions in ant numbers were obtained with bait stations placed at 100 ft intervals. The methoprene product was ineffective for the first 8 weeks of the study, followed by a crash in the ant population. Collection of ants from the plots confirmed the impact of the methoprene on the ant queens in the treated plot.

117. FROM DEVELOPMENT TO PRACTICE: LABELING NEW BAIT TECHNOLOGY FOR AGRICULTURE

Keith Dorschner

IR-4 Project Headquarters, Rutgers, The State University of NJ, 500 College Road East, Suite 201 W, Princeton, NJ 08540

The Environmental Protection Agency (EPA) and the U.S. Department of Agriculture (USDA) recognize that a variety of pest management tools are needed in order to maintain a safe and dependable supply of fruits and vegetables. Access to such pesticide tools also enables the management of pest resistance, reduces the risk of pest-born diseases and enables more effective integrated pest management programs. However, pesticide use raises concerns of health and environmental impacts, so Federal law requires that pesticide applications must be registered by the U.S. EPA before use is allowed. Pesticide registration can be a daunting task, requiring years for data collection by the Registrant Company and regulatory approval by EPA. The IR-4 Project is funded by USDA to assist specialty crop growers in this expensive, time-consuming task. Ant baiting technologies are unique in that only very small amounts of toxicant are required for control. Furthermore, the baits can be delivered in bait stations which limit exposure to pesticide contamination of the crop and the environment. IR-4 was successful in convincing EPA that the use of pesticide baits delivering in approved bait stations to control ants in perennial crops should be considered a "non-food" use. This means that individual tolerances for the pesticide on the crop are not required as for, say, a foliar spray of a pesticide to the crop. This has resulted in a streamlined registration process for bait technologies delivered in bait stations.

118. COMPARING ARGENTINE ANT INVASIONS IN PRESERVES AND AGRICULTURAL SETTINGS

Jessica W. Shors and Deborah M. Gordon

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We compare the dynamics of Argentine ant *Linepithema humile* invasions in preserves and agricultural settings. Using our 14-year study of the Argentine ant invasion at Stanford University's Jasper Ridge Biological Preserve, we discuss similarities and differences between that invasion and those in northern California vineyards and citrus groves. We consider how outcomes differ in preserves and agricultural sites, comparing nesting behavior, invasion rates, and impact of invasion on native ants and hemipterans. Site characteristics that affect outcomes include vegetative cover, irrigation regimes, proximity to urban development, and soil nitrogen content.

119. CONTROLLING ANTS WITH TOXIC BAITS AND ITS IMPACT ON VINE MEALYBUG INFESTATIONS IN COACHELLA VALLEY VINEYARDS

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The ant *Formica perpilosa* Wheeler tends the vine mealybug, *Planococcus ficus* (Signoret) on table grapes grown in the Coachella Valley, California, thereby disrupting biological control of the mealybug. In addition, the ant facilitates the survival of *P. ficus* belowground on the vine trunk and roots during the extreme desert temperatures. We evaluated toxic granular ant baits delivered in stations against *F. perpilosa*. The application timing, baiting rate (g/nest), distribution of stations, and the impact of controlling *F. perpilosa* on populations of *P. ficus* were studied. In vineyards > 5 years of age, bait applied in early June controlled *F. perpilosa* more effectively than when it was applied in late June. There was no difference, however, in the effectiveness of bait applied on 16 June or 16 July in a vineyard < 2 years of age. Advance® 375 Granular Ant Bait effectively controlled *F. perpilosa* at 15 g per nest for up to 119 d after treatment. The effective range of a bait station was limited to 2.13 m. At distances > 2.13 m ant activity was not affected. The reduction in ant activity was accompanied by a significant reduction in mealybugs. Based on our findings, we recommend treating each nest in infested vineyards to optimize ant control. Using this baiting program, we estimated a potential reduction in cost of ca. 26% to control economic populations of *P. ficus* versus imidacloprid and chlorpyrifos.

120. VIRTUAL BAITS – THE ROLE OF HORIZONTAL TRANSFER OF INSECTICIDES

Dong-Hwan Choe and Michael K. Rust

Department of Entomology, University of California, Riverside

Several ant species have become serious pests in agricultural settings, especially when they tend phloem-feeding homopterous pests producing honeydew. When the application of broad-spectrum residual insecticides is of concern, the use of baits has been one approach to control ants in these areas. However, baiting has several problems such as finding universal bait bases and attractants, formulating insecticides into acceptable baits matrices, and the cost of maintaining baiting programs. To overcome these problems, we have a new approach that we refer to as "Virtual Baiting." Our approach exploits the foraging / recruitment behavior and necrophoresis (i.e., carrying dead nestmate) of worker ants and avoids the need of formulating special toxic baits. In the process of foraging on attractive food substances or responding to pheromones, the ants contact lethal doses of insecticide and transport them back to the colony. Laboratory tests and field evaluation to develop effective virtual bait station will be discussed.

121. CASCADING EFFECTS OF PREDATOR BIODIVERSITY ON THE FUNCTIONING OF FOOD-WEBS: A REVIEW

Bradley J. Cardinale

University of California - Santa Barbara, Department of Ecology, Evolution, and Marine Biology

One of the fastest growing topics of research over the past decade has been the impacts of Biodiversity on Ecosystem Functioning (BEF). BEF seeks to understand how the number of genotypes, species, and functional groups of organisms comprising a community can impact the magnitude and rates of ecological processes. Although its inception is often attributed to grassland ecologists studying how plant diversity impacts production, the BEF paradigm has its roots in predator-prey ecology where there is a long-history of interest in multi-enemy impacts on pest population dynamics. Here I review recent theoretical and empirical advances that examine how predator species richness impacts the dynamics of predator and prey populations. Mathematical models suggest that a myriad of indirect, non-additive and behavioral interactions allow predator species richness to have far more variable impacts on the dynamics of predators and prey than has been observed for systems with a non-dynamic resource (i.e. plants 'consuming' nutrients). A meta-analysis of recent predator diversity experiments suggests that decreases in predator richness usually reduce the combined density of predators, but alter the density of prey in just 38% of experiments. Diverse predator assemblages achieve higher predator densities than the most efficient predator in 50% of experiments, and lower prey densities than the most efficient predator in just 35%. These results suggest that, at present, there are a limited number of generalities in how predator diversity impacts biological control. I'll end my talk with several challenges that may help us extend these generalities in the near future.

122. ENEMY DIVERSITY AND THE SUCCESS OF CLASSICAL BIOLOGICAL CONTROL

Nick Mills
Department of Environmental Science, Policy and Management, University of California, Berkeley, CA

One of the most challenging questions in biological control has been whether the single best natural enemy will provide greater suppression of the abundance of an arthropod pest than a combination of natural enemies due to the effects of competition for a shared resource (the pest). From a theoretical perspective, simple predator-prey models clearly indicate that for multiple natural enemies sharing a single pest, only a single natural enemy will persist in the system, the species that can reduce the pest to the lowest equilibrium density. In addition, the biological control record of natural enemy introductions against invasive insect pests suggests that establishment rates are higher for projects with single versus multiple introductions, and that competitive exclusion can result from a sequence of parasitoid introductions against a pest. From natural field populations, however, it is clear that insect herbivores frequently support a diverse assemblage of both parasitoid and predator species suggesting that resource partitioning can

mediate the effects of competition. So how important are competitive interactions in the context of biological control? Here, I consider the asymmetries of competition among natural enemies of arthropod pests, the incidence of competitive exclusion, the mechanisms of coexistence and their consequences for the success of biological control.

123. NATURAL ENEMY DIDVERSITY ENHANCES THE TOP-DOWN SUPPRESSION OF HERBIVORE COMMUNITIES

William E. Snyder

Washington State University, Pullman, WA

Species diversity at lower trophic levels generally improves ecosystem functioning. However, the impact of greater predator diversity on herbivore regulation is uncertain because predator species both compete with and prey on each other. In a large-scale field experiment we examined the relationship between predator species diversity and the suppression of two herbivores, green peach and cabbage aphids, on collard plants. We show that, for both aphid species, the strength of herbivore suppression increased with higher predator biodiversity. Greater resource exploitation by predators in diverse communities generally led to improved predator survivorship and reproduction. Herbivore population size was negatively correlated with plant biomass, providing evidence that greater aphid suppression leads to improved plant growth. Our work suggests a harmonious relationship between predator conservation and herbivore control, and a relatively weak role for predator interference, within this community.

124. SCALES OF SPACE AND TIME AND THE BENEFITS OF ENEMY DIVERSITY

Edward W. Evans

Department of Biology, Utah State University, Logan, UT

Increasing diversity of natural enemies can result in either heightened or diminished control of target pests. Further, the net impact of an assemblage of natural enemies (with attendant interactions among species, such as competition, intraguild predation, and mutualism) will vary with spatial and temporal scales. Given the apparent universality of niche differentiation, it seems a reasonable working hypothesis that in general, net benefits of natural enemy diversity (i.e., the degree to which interacting natural enemies may combine to reduce population levels of pests) will increase as larger spatial scales and longer time scales are considered. In assessing this general hypothesis (essentially one of species complementarity), I will present a case study of seed feeding insects attacking a weed (squarrose knapweed, *Centaurea virgata var. squarrosa*) in the west desert of Utah. The nature of species interactions among the insects and their host weed will be examined for spatial scales varying from a single seed head to large-scale populations of seed heads distributed over hundreds of square kilometers, and for temporal scales varying from within a single flowering season to a period of decades encompassing wide variation in the abiotic conditions upon which biotic interactions are staged.

125. NATURAL ENEMY DIVERSITY DOES NOT NECSSARILY ENHANCE WEED BIOLOGICAL CONTROL EFFICACY

Mark Schwarzländer[1] and Hariet L. Hinz [2]
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The successful suppression of invasive exotic plants by herbivore insects and mites used in classical biological control programs is assumed to increase with natural enemy diversity. Commonly referred to as 'Multiple Stress Hypothesis' in the research field, there are however, surprisingly few empirical studies examining positive or synergistic effects of biological weed control agent diversity. In contrast, there exist examples for plant mediated competitive effects between natural enemies that negatively affects overall weed suppression rate. Natural enemy diversity effects on weed suppression for herbivore arthropods and mammalian grazers can range from positive to negative. The majority of interspecific effects between plant competition and herbivore insects are however positive or synergistic compared to the effect of plant competition or insect herbivores alone. We will review examples for natural enemy diversity effects in biological weed control and argue that there is no simple correlation between natural enemy diversity and exotic invasive plant suppression.

126. COMMUNITY-BASED CONSERVATION BIOLOGICAL CONTROL: SUCCESSFUL EMPLOYMENT IN FOUR AGROECOSYSTEMS

David G. James

Washington State University, Department of Entomology, Irrigated Agriculture Research and Extension Center, 24106 North Bunn Road, Prosser, WA 99350

Developing diversified and robust communities of natural enemies is usually considered to be a prerequisite for improving conservation biological control in agroecosystems. Until recently, such a goal was difficult to achieve in many crops because of chemical inputs that were invariably damaging to most predators and parasitoids. However, with the increased availability of selective, natural enemy-friendly chemicals, communities of beneficial insects can now be encouraged in some cropping systems. Examples are provided of four cropping systems in Australia and Washington State, in which communities of natural enemies have been developed and are utilized by growers to provide improved conservation biological control of pest arthropods.

127. CASCADING EFFECTS OF PREDATOR-PATHOGEN COMPLEMENTARITY

Ricardo A. Ramirez and William E. Snyder

Washington State University, Department of Entomology, FSHN 166, Pullman, WA

Herbivore suppression often strengthens with increasing predator biodiversity, but less is known about the role of pathogens in these relationships. Because of their different functional roles, predators and pathogens might exert complementary impacts on herbivores. Colorado potato beetle eggs and small larvae occur in plant foliage where they are attacked by a guild of generalist predators, whereas later-stage larvae burrow into the soil to pupate and are attacked by a guild of insect pathogens. We manipulated predator-pathogen species richness and found that potato beetle densities decreased, and plant biomass increased, with greater natural enemy biodiversity. However, herbivore suppression strengthened only for predator-pathogen pairs, and not for pairings within the same natural enemy guild. In the laboratory, exposure to the threat of predation weakened beetles' immune response. Clearly, the combination of predators with pathogens is particularly deadly for this herbivore, perhaps because of a tradeoff in defenses against these two enemy guilds.

128. ENEMY DIVERSITY AMPLIFIES THE CASCADING EFFECTS OF FEAR

S.A. Steffan and W.E. Snyder

Department of Entomology, Washington State University, Pullman, WA

Herbivore suppression often strengthens with greater predator biodiversity, indirectly benefiting plants. However, it is unclear how the relative importance of lethal and non-lethal predator effects scale across levels of species richness. We experimentally isolated predator species richness, and lethal and non-lethal predator effects, to measure the role of each in protecting collard plants from herbivorous diamondback moth larvae. Plant biomass was greatest where diverse predator communities induced anti-predator behavior in herbivores, an interactive effect not further strengthened when predators could also suppress caterpillar densities. Consistent with these indirect effects on plants, greater enemy richness did not significantly alter caterpillar densities but did induce higher rates of anti-predator behavior. Incidence of anti-predator behavior and trophic cascade strength consistently increased among diverse species compositions, suggesting an effect of predator biodiversity *per se*. Thus, we demonstrate that the interaction between non-lethal effects and species richness can amplify predator effects in species-rich communities.

129. CONSERVATION AND RESTORATION OF AN ECOSYSTEM, THE ROLES OF POLLINATION AND INVASION

P. Aldrich

Department of Zoology, University of Hawaii, Manoa, HI

Hawaiian tropical dry forests in particular, are one of the most endangered ecosystems in the world. Currently, less than 10% of these forests remain, and what is left is highly degraded and found in small remnant patches. Non-native plants and insects dominate the landscape in and around these remnant patches. Interactions between native and non-native species need to be understood if conservation and restoration of dry forests is to be obtained. Within the Hawaiian dry forests, we find that native pollinators almost exclusively interact with native plants, while non-native pollinators interact with both native and non-indigenous plants. European honey bees, which are by far the most ubiquitous flower visitor in the system, visit almost every plant regardless of group or density, including four species of invasive plants which are visited by no other pollinators. Yet, this species is also the only visitor to several highly endangered plant species whose individuals are widely dispersed through the landscape. This is what I call the honey bee conundrum, and removal of honey bees from the system will have both positive and negative affects. We must determine which effect outweighs the other before any conservation actions are taken.

130. SHARPSHOOTERS CAUGHT IN BIOLOGICAL CROSSFIRE: IMPLICATIONS FOR HOST-SPECIFICITY TESTS IN FUTURE CLASSICAL BIOCONTROL PROGRAMS

Elizabeth A Boyd[1,2] and Mark S. Hoddle[2]

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Classical arthropod biological control programs lack a broadly utilitarian and standardized risk assessment testing strategy for precisely estimating physiological and ecological host range of potential biological control agents. Several different testing strategies have been proposed, yet few have been implemented or adopted universally and subsequently evaluated in terms of efficacy at estimating realized risk. In work presented here, we evaluated a rigorous host specificity testing protocol for estimating potential physiological and ecological risk to non-target species posed by exotic parasitoids being used in a classical biological control program. This testing strategy was evaluated at two environmental scales, micro-scale Petri dish studies and macro-scale cage studies, with choice and no-choice host options presented on multiple plant species to two related egg parasitoids with dissimilar life history strategies. The natural enemies tested were the solitary *Gonatocerus ashmeadi* Girault and the gregarious *G. fasciatus* Girault (Hymenoptera: Mymaridae). Both are non-native egg parasitoids of the exotic glassy-winged

sharpshooter (GWSS), *Homalodisca vitripennis* (Germar) (Hemiptera: Cicadellidae), and were introduced as part of the GWSS classical biological control program in southern California, U.S.A. For both parasitoids, the physiological and ecological host ranges were estimated on three non-target indigenous sharpshooters, the smoke-tree sharpshooter (STSS), *Homalodisca liturata* Ball, the blue-green sharpshooter (BGSS), *Graphocephala atropunctata* (Signoret), and the green sharpshooter (GSS), *Draeculacephala minerva* Ball (all Hemiptera: Cicadellidae). Results of this host specificity testing strategy were further evaluated by comparing laboratory results with observed non-target impacts against the three principle native cicadellid species by *G. ashmeadi* and *G. fasciatus* in the field. Implications for non-target host specificity testing in future classical arthropod biological control programs will be discussed.

131. THE BREADTH, BENEFIT, AND FUN OF INSECT SYSTEMATICS: AN EXAMPLE WITH THE ANT GENUS *STENAMMA*

M. Branstetter

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Systematics is the scientific discipline of discovering, describing, and classifying the diversity of life on Earth and it is of fundamental importance to biology. Often wrongfully perceived as being a dull, mechanical science, systematics is in fact an extremely dynamic, diverse, and enlightening pursuit, integrating and contributing to a wide range of fields, such as biogeography, evolutionary biology, and phylogenetics, as well as more applied disciplines like integrated pest management and conservation biology. In this talk I will describe my perspective on the broader impacts of insect systematics using research on the taxonomy, phylogeny, and natural history of the ant genus *Stenamma* as an example. *Stenamma* is a little studied genus of ants that is most diverse and abundant in the leaf litter of mid-elevation mesic forest habitats. Most of the diversity is found within the Holarctic region, but recent focus on tropical leaf litter is revealing a surprising number of new species, particularly in the Neotropics. My research seeks to put the Neotropical taxa into a phylogenetic and biogeographic framework that will facilitate a clade-based species-level revision while also allowing me to test the hypothesis that the genus originated in the temperate zone and dispersed into the tropics. Additionally, I hope to add to our knowledge of *Stenamma* natural history by studying the proximate and ultimate causes of a unique suite of nest-defense behaviors found in several tropical species.

132. TALES FROM THE MARSH: CONTROLLING MOSQUITOES AND CONSERVING FISH

Jennifer Henke

Department of Entomology, University of California, Riverside, CA 92521

Freshwater species are disappearing at a rate comparable to losses in tropical forests. These losses can partially be attributed to eutrophication, which is expected to triple by 2050. In

wastewater and mitigation wetlands, the nutrient level is already much higher than that of natural wetlands and can result in simpler yet more productive invertebrate communities. This shift can lead to a greater production of pestiferous insects, yet our understanding of food web dynamics in wetlands is poor due to a lack of tools such as functional feeding groups employed by stream ecologists. My research focuses on using native fish to control larval mosquito populations as well as how human impacts affect wetland invertebrate communities.

133. SURVEY OF PREDATORY MITES IN CALIFONIA AGRICULTURE

Maria Murrietta, David Headrick
Horticulture and Crop Science Department, California Polytechnic State University, San Luis Obispo, CA

Phytoseiidae are predatory mites that feed on many types of phytophagous mites (*Tetranychidae*) commonly found in agricultural production. More than 2,500 phytoseiid species have been identified world wide. The majority of the 68 species found in California were identified in the 1960s and 70s when spray programs heavily favored organophosphates and carbamates. Management practices have since changed to include low-risk insecticides that are less toxic to non-target organisms. A survey of naturally occurring phytoseiids will provide documentation of any changes in the predator complex that may have resulted from the change in management practices.

A two-season survey of avocados, cherimoyas, grapes, strawberries, and caneberries in San Luis Obispo, Santa Barbara, and Ventura Counties was conducted to identify the phytoseiid species found in these crops on the Central Coast. Adult female phytoseiids were collected twice a month from March through October, 3-6 sites per crop, for a total of 21 locations.

Euseius stipulatus was most abundant in avocados showing 99% of the 249 phytoseiids collected while *E. quetzali* made up 1%. *E. stipulatus* also was the most dominant predator in the cherimoyas with 98% of the 304 phytoseiids collected and *Amblyseius similoides* made up the remaining 2%. *Amblyseius limonicus* made up 55% of the 467 predators collected from raspberries. *Euseius stipulatus* made up 20%, *Neoseiulus californicus* 11% and *Phytoseiulus persimilis*, *Metaseiulus johnsoni, Typhlodromina ehari* made up the remaining 14%. *Neoseiulus californicus* made up 48% of the 98 phytoseiids collected in blackberries and *Galendromus annectans* 25%. *Galendromus occidentalis*, *T. ehari* and *A. limonicus* made up the remaining 27%. *Neoseiulus californicus* was dominant in strawberries showing 93% of the 269 phytoseiids collected and *P. persimilis* made up the remaining 7%.

134. A NEW METHODOLOGY FOR TESTING FOR NICHE PARTITIONING IN INSECT PREDATOR COMMUNITIES

Tobin D. Northfield, Gretchen B. Snyder, William E. Snyder

Department of Entomology, Washington State University, Pullman, WA 99163

Niche partitioning often leads to increased prey suppression with increased predator biodiversity by increasing the proportion of prey available to the predator community. However, it can be difficult to convincingly document that niche partitioning occurs, so we have developed a new methodology to test for niche partitioning by quantifying the niche breadth of predators. We used a hyperbolic decay model to estimate the number of aphids remaining on collard plants after 31 days, in a large scale field experiment wherein predator density was manipulated in cages with high or low predator diversity. The model was fit separately for each species assemblage and reaches a horizontal asymptote that predicts the number of prey remaining after being exposed to an infinite number of predators (the number of prey occupying predator-free niches). Comparing the asymptotes allowed us to test for an increase in functional niche space occupied by predators with increased predator diversity. In our study the functional niche space occupied by the diverse group of predators was significantly greater than the single species treatments, indicating that niche partitioning occurred. This methodology can be used in a wide range of insect communities to gain insight into the role that predator niche partitioning plays in driving biodiversity-biocontrol relationships.

135. PHYLOGENETICS AND EVOLUTIONARY TRENDS IN LEIODIDAE (COLEOPTERA: STAPHYLINOIDEA)

Ainsley Seago

137 Mulford Hall, Department of ESPM, University of California, Berkeley, CA

The beetle family Leiodidae occurs worldwide and encompasses a tremendous breadth of morphological and ecological diversity, including iridescent fungivores, eyeless, wingless cave-dwellers, and mammalian ectoparasites. An improved understanding of leiodid evolutionary relationships makes it possible to examine how and why these unusual lifestyles have evolved.

In order to determine the phylogenetic relationships within Leiodidae, a multilocus DNA dataset was assembled for multiple representatives of all subfamilies and 17 of the family's 19 described tribes. Comparative methods applied to this phylogenetic framework indicate that trophic specialization has led to substantial evolutionary diversification in certain leiodid lineages. In inquiline, phoretic, and ectoparasitic beetles, however, no such radiations appear to have occurred.

136. TOXICOLOGICAL STUDIES OF NOVEL REDUCED-RISK INSECTICIDES ON OBLIQUEBANDED LEAFROLLER

Ashfaq A. Sial and Jay F. Brunner

Department of Entomology, Washington State University Tree Fruit Research and Extension Center Wenatchee WA

The obliquebanded leafroller (OBLR) C*horistoneura rosaceana* (Lepidoptera: Tortricidae) is one of the most destructive pests of tree fruits in Washington. Organophosphates (OPs) have been used to control OBLR for decades which led to the development of OP resistance and some cross-resistance to other groups of insecticides. The development of insecticide resistance and increased public concern over health and environmental effects of broad-spectrum insecticides has led to the development of environmentally benign and highly selective insecticides. Some of the reduced-risk insecticides with novel modes of action (Emmamectin benzoate™, spinetoram™, and rynaxypyr™) have recently been developed as OP replacements for OBLR control. These insecticides were highly effective against OBLR in preliminary bioassays. Our surveys indicate a low level of rynaxypyr™ resistance in two field-collected OBLR populations, even before its use in the field. Preliminary results of our selection experiments indicate some potential of OBLR to develop resistance against these newly developed insecticides. The progression of resistance development in laboratory will provide clues to the risk of OBLR resistance in the field.

Efforts to manage resistance have been limited by our understanding of the genetics of insecticide resistance and underlying molecular mechanisms which is crucial for the development of tactics to slow evolution of resistance in OBLR. Therefore I plan to investigate the potential of OBLR to develop resistance against these insecticides, and the genetic and molecular bases of resistance. This information will enable growers, pest management consultants, and researchers to detect resistance in OBLR in the early stages of its development, and design IPM strategies to preserve OBLR susceptibility to these novel chemistries. This research will promote environmental stewardship by the prolonged use of highly target-specific and environmentally friendly insecticides.

137. CONTROLLING ANTS WITH TOXIC BAITS AND ITS IMPACT ON VINE MEALYBUG INFESTATIONS IN COACHELLA VALLEY VINEYARDS

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The ant *Formica perpilosa* Wheeler tends the vine mealybug, *Planococcus ficus* (Signoret) on table grapes grown in the Coachella Valley, California, thereby disrupting biological control of the mealybug. In addition, the ant facilitates the survival of *P. ficus* belowground on the vine trunk and roots during the extreme desert temperatures. We evaluated toxic granular ant baits delivered in stations against *F. perpilosa*. The application timing, baiting rate (g/nest), distribution of stations, and the impact of controlling *F. perpilosa* on populations of *P. ficus* were

studied. In vineyards > 5 years of age, bait applied in early June controlled *F. perpilosa* more effectively than when it was applied in late June. There was no difference, however, in the effectiveness of bait applied on 16 June or 16 July in a vineyard < 2 years of age. Advance® 375 Granular Ant Bait effectively controlled *F. perpilosa* at 15 g per nest for up to 119 d after treatment. The effective range of a bait station was limited to 2.13 m. At distances > 2.13 m ant activity was not affected. The reduction in ant activity was accompanied by a significant reduction in mealybugs. Based on our findings, we recommend treating each nest in infested vineyards to optimize ant control. Using this baiting program, we estimated a potential reduction in cost of ca. 26% to control economic populations of *P. ficus* versus imidacloprid and chlorpyrifos.

138. IS THE POTATO TUBERWORM AN EXOTIC OR INVASIVE PEST THAT THREATENS THE PACIFIC NORTHWEST'S AGRICULTURAL AREA?

Silvia I. Rondon

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The potato tuber worm (PTW) *Phthorimaea operculella* (Zeller) is by far one of the most important constraints to potato productivity worldwide. It was first detected in Oregon (Hermiston area) in 2002. In the U.S., PTW has been found in California, Arizona, New Mexico, Utah, and as far east as in Maryland and Virginia. In 2003, potatoes from several fields in Oregon and Washington were rejected due to PTW damage resulting in a large economic loss. Economic loss increased substantially in 2004 and 2005, due to increased PTW population densities. A pheromone trapping network throughout the potato production area of north eastern OR and central WA has documented an increase in PTW range of nearly 100 miles north into WA in just two years. In 2006, a report confirms the presence of PTW in central and western OR and in at least two counties in western ID. Distribution and population information for the northwestern U.S. is incomplete at this time. Control of PTW damage is critical because its larvae infest tubers (in the field as well as in storage), rendering them unmarketable. There is a zero level of tolerance in processed potatoes. Direct control through the use of insecticides is expected to climb as PTW range and population densities increase. Besides knowing the biology, ecology and dynamic of this pest is important to determine the origin of PTW Columbia Basin populations since that will help us understand how they were introduced and how to prevent further introductions.

139. RESEARCH AND OBSERVATIONS ON CEREAL LEAF BEETLE IN SE WASHINGTON STATE

David Bragg

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Cereal Leaf Beetle, *Oulema melanoplus,* has been present on cereal crops and grasses in the PNW about 10 years. At first it was a state regulated insect with eradication the goal. Any live CLB in an entire field resulted in full field sprays. This is still true in some places. Early research demonstrated that any general insecticides would eradicate not only the CLB but most of the fauna present in the habitat. Continuing emphasis on biological control of CLB with Hymenopterous parasitoids (*T. julius*) is very successful in protected ecosystems such as a grower cooperator creating a no spray area to protect the wasps. The problem being a continued drive to kill them all by neighboring county advisors and field scouts. Seed treatment insecticides are fairly safe to natural enemies based on trials. Predators have simply not considered in depth by most PWN researchers. The usual trend is to consider all predators obtained in traps and by Divac to be feeding on CLB. Coccinellid beetles, *Hippodamia convergen*s, feed directly on all instars from egg to early 3rd instar larvae. Natural enemies attacking CLB larvae must deal with the fecal coat common to the Chrysomelid beetles. H. convergens pushes the larva over and bites into the ventral surface to eviscerate the larva leaving the skin behind as evidence. *T. julius* parasitizes as a pupal parasitoid, and it inserts the ovipositor under the beetle into the ventral skin to avoid the fecal coat. Predators can reduce the CLB population by 40%. Parasitoids further reduce late instar CLB larva and prepupal populations up to 93% at Central Ferry WA.
An IPM System for cereal leaf beetle could be three fronted – seed treatments, encouragement of predators, and establishment of parasitoid refuges. Some growers of wheat are adopting these strategies now.

140. VARIABILITY IN THE INVASIVENESS, OR LACK THEREOF, OF THE EXOTIC MEALYBUG *FERRISIA GILLI* INTO CALIFORNIA'S TREES AND VINES

David Haviland[1], Kris Godfrey[2], Kent Daane[3]

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Successful invasion of a new exotic agricultural pest can be influenced by many factors. Some examples include availability of host plants, environmental conditions, status of biological control and pesticide control programs. In the case of *Ferrisia gilli*, a new pest of deciduous trees and vines in California, all of these factors have contributed to either the widespread success, or utter failure of this pest in becoming permanently established. This presentation will use case studies from Gill's mealybug's attempts at invasion of pistachios, almonds, persimmons and grapes in California to help explain both the successes and failures of this pest. Topics will

include pesticide programs used in each of these crops, species composition of biological control organisms and variations in environmental conditions among new invasion sites. Information will also be provided on the relative successes of integrated pest management programs for this pest in locations where it has become permanently established.

141. OLIVE FRUIT FLY: A HIGHLY SUCCESSFUL INVASIVE SPECIES IN CALIFORNIA

Marshall W. Johnson[1], Hannah Nadel[1], Kent M. Daane[2], Karen R. Sime[2], Xingeng Wang[1], Kris Lynn-Patterson[3], Charles H. Pickett[4]

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Olive fruit fly, *Bactrocera oleae* (Rossi)(Diptera: Tephritidae), is the major pest of olives worldwide. Although olives have been grown in California for greater than 225 years, olive fruit fly was only first discovered in the state in 1998. Within 4 years, the pest had established in most regions where olive trees were grown. Many factors apparently contributed to this success including: availability of olive plantings in urban and agricultural areas, California's mild climate, lack of effective natural enemies (native and introduced), movement of infested olive fruit within the state, lack of effective management methods during the years shortly after introduction, and no readily-available eradication protocol to combat the invader. The olive fruit fly differs in its impact upon olives grown for curing (i.e., table olives) versus those grown for oil, with the former being more impacted due to cosmetic reasons. Approximately one decade after its discovery, management programs (e.g., application of GF-120 bait sprays) have been established for olive fruit fly, but are still being refined to obtain maximum efficiency. Exotic biological control agents have been imported and are undergoing testing to determine their host specificity and potential as control agents in various olive growing localities.

142. LBAM IN CALIFORNIA: BIOLOGY AND MANAGEMENT OF A NEW INVADER

Nick Mills

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The confirmation of LBAM (*Epiphyas postvittana*) in California in March 2007 posed a new threat to the agricultural and horticultural industries of California, with the potential to cause millions of dollars in damage. It has subsequently been found in 8 San Francisco Bay Area counties and in Monterey, Santa Cruz and Los Angeles counties, and climate niche models suggest that it has the potential to spread throughout the western region. LBAM originates from

SE Australia, where it has been recorded from more than 250 plant species including crops, trees and ornamentals and thus California and the western region provide ample opportunity for establishment of this new pest. Here I review the biology and phenology of LBAM, the management options that are in use in Australia and New Zealand, the current eradication program in California, and the opportunities for classical biological control of LBAM should it become more widely established.

143. ERYTHRINA GALL WASP: A THREAT TO CALIFORNIA AND BEYOND

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The Erythrina gall wasp *(Quadrastichus erythrinae),* most likely of African origin, first invaded Hawaii in 2005, and quickly spread across the entire archipelago. Simultaneously it invaded several other Pacific Islands and many countries in Asia. The wasp quickly kills even large ornamental Erythrina trees, and is also having a severe impact on the endemic *Erythrina sandwicensis*, which is considered a keystone species in Hawaii's few remaining lowland forests. The wasp appears to spread very rapidly, probably in leaves containing galls, and has recently been found in Florida. With the large amount of commerce and tourism between Hawaii and California, the wasp is likely to invade and kill many of the thousands of ornamental Erythrina trees from San Diego up to Santa Barbara. It also threatens the native *Erythrina flabelliformis* in Arizona and New Mexico, *E. herbacea* across the southeastern U.S., and many *Erythrina* species throughout Central and South America.

Foreign exploration in Africa and Madagascar has yielded several potentially effective parasitoids of the gall wasp. These are currently being tested in quarantine, and so far one Eurytomid species is considered safe and is awaiting field-release permits. Biological control is the only tool likely to be effective for the management of gall wasp populations; meanwhile the threat of extinction of endemic plant species highlights the need for a rapid response biocontrol permit system.

144. THE CALIFORNIAN SOURCE OF HAWAII'S ASTER LEAFHOPPER (*MACROSTELES*) AND POTENTIAL FUTURE THREATS FOR BOTH REGIONS

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An exotic, but unknown species of Aster leafhopper (*Macrosteles* sp.) was discovered on the island of Oahu, Hawaii in 2001. This species transmits the Aster Yellows Phytoplasma in water cress farms, devastating the local industry, and necessitating heavy pesticide application. The

identity and origins of this *Macrosteles* remained unclear until now. Further, while the insect is able to feed on and transmit the Phytoplasma to a wide range of plants in greenhouse conditions, it remains restricted to the watercress farms and has not spread beyond Oahu.

Morphological characters have been ambiguous in resolving many questions about *Macrosteles* systematics, leading to confusion regarding species boundaries, identity and vector potential. We used molecular sequence data from the mitochondrial genes cytochrome oxidase I and nicotinamide adenine dehydrogenase and the nuclear gene elongation factor 1 alpha to broadly examine the systematics of common North American *Macrosteles*, with special focus on the species in California and Hawaii. Our results suggest that southern California is likely the origin and original range of the Hawaiian invader. Additionally, the phylogeny suggests that while some species of *Macrosteles* are migratory and widespread, others appear to be localized and cryptic. Introduction of localized sedentary species may pose less of a risk in the short term, but still have the potential to act as severe pests. Accurate identification and exclusion of migratory species is likely to be essential to preventing more rapid and wide scale agricultural and ecological damage.

145. USING MONITORING DATA TO MANAGE YELLOWJACKET WASPS IN HAWAII.

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Introduced western yellowjacket wasps, *Vespula pensylvanica*, are a threat to arthropod biodiversity in native ecosystems including National Parks and Refuges of Hawaii. Wasp populations are presently monitored using non-toxic plastic traps baited with heptyl butyrate and checked monthly for *Vespula* workers. The population monitoring program for yellowjacket wasps will be reviewed and its application to effective wasp control programs will be discussed.

146. PROTECTING CALIFORNIA FROM INVASIVE ARTHROPODS: THE IMPORTANCE OF EXCLUSION AND EARLY DETECTION

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California employs a multi-tiered approach to prevent the introduction and establishment of invasive arthropods. International pathways are addressed by United States Department of Agriculture (USDA) regulations and port of entry inspections. Domestic pathways are addressed by USDA quarantines, California Department of Food and Agriculture regulations, border

station inspections on key highways, and county-level inspections of material brought into the State. A specialized exclusion program aimed at preventing the establishment of Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), uses the sterile insect technique continuously over 2500 square miles of the Los Angeles basin. The final tier is a statewide detection program that couples with an eradication infrastructure to find and eliminate fledgling populations before they can become permanently established. Pests that are detected and eradicated on an annual basis are gypsy moth, *Lymantria dispar* (L.); Japanese beetle, *Popillia japonica* Newman; and several species of exotic fruit flies (Tephritidae).

Despite these efforts, invasive arthropods continue to arrive in California, and in some cases become established. A common thread between those that do become established is a lack of an adequate detection system. Recent invaders that have become established and are under active eradication efforts are red imported fire ant, *Solenopsis invicta* Buren; Diaprepes root weevil, *Diaprepes abbreviatus* (L.); and light brown apple moth, *Epiphyas postvittana* (Walker). Others that have been detected in the past five years and for which no eradication efforts are planned include large yellow underwing, *Noctua pronuba* (L.); olive psyllid, *Euphyllura olivina* (Costa); Mediterranean pine engraver, *Orthotomicus erosus* Wollaston; a chrysomelid beetle, *Chrysolina bankii* (F.); somber carpet, *Disclisioprocta stellata* (Guenee); brown marmorated stink bug, *Halyomorpha halys* (Stål); and a thrips *Klambothrips myopori* Mound and Morris.