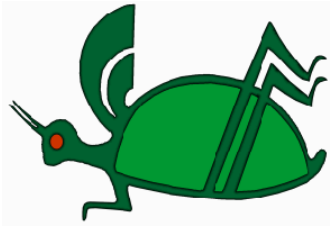
ABSTRACTS

(Alphabetical by First Author)



"INVASIVE SPECIES OF THE PACIFIC REGION"

PACIFIC BRANCH
OF THE ENTOMOLOGICAL SOCIETY OF AMERICA

NINETY-FIFTH ANNUAL MEETING

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INTRODUCTION, RELEASE AND RECOVERY OF THE APHID PARASITOID *BINODOXYS COMMUNIS* FOR IMPROVED APHID CONTROL IN HAWAII

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Aphids are among Hawaii's most destructive insect pests, and farmers need more affordable and sustainable ways to manage these invasive species. The aphid parasitoid, *Binodoxys communis* (Hymenoptera: Braconidae: Aphidiinae) was recently introduced into Hawaii to help improve the biological control of aphids. The main target species of this parasitoid is the melon aphid, *Aphis gossypii* Glover, which transmits viral diseases in agricultural commodities such as taro, cucumber and papaya. In order to evaluate the establishment of this aphid parasitoid in the field, we collected a series of samples from three field sites on the island of Kauai before and after the release of *B. communis*. We examined the effects of the introduction on aphid density, overall levels of primary and secondary parasitism, and abundance of previously established parasitoid species. *Binodoxys communis* adults were released and evidence of establishment was observed at all three field sites. However, *B. communis* populations did not persist at high levels throughout the sampling period, and aphid densities did not decrease following the introductions. The former could be due to high rates of hyper-parasitoid attack, which were observed in all field sites. Because of the relatively short-term evaluation period and the low recovery of *B. communis* in the field, corresponding changes in aphid density, overall parasitism rates, and extant parasitoid abundance cannot yet be directly attributed to this new parasitoid.

A MAJOR CANEBORING PEST OF RASPBERRY IN THE INTERMOUNTAIN WEST, RASPBERRY HORNTAIL, *HARTIGIA CRESSONI* (HYMENOPTERA: CEPHIDAE)

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Hartigia cressoni (Kirby) is currently the most economically important caneboring pest of raspberry in northern Utah. Infestations can be severe (up to 85% of canes) in commercial raspberry fields. It has displaced the rose stem girdler, *Agrilus aurichalceus* Redtenbacher (Coleoptera: Buprestidae), as the primary caneboring pest of raspberry. It was first documented in Utah in Box Elder County in the 1980s, and is known to occur in other western states, including CA, CO, and ID. It is univoltine and overwinters within canes as a last-instar larva. Pupation occurs in the spring and adults emerge and lay eggs on raspberry primocanes through early summer. Early season cane sampling to detect young instars and tunnels in the cambium was unsuccessful. In 2009 and 2010, the first indication of cane infestation was on 24 June and 1 July, respectively. We found that larvae fed heavily and molted to the last instar at the cane tip. Intense larval feeding induced cane-tip wilting. Larvae then made a u-turn and tunneled downward to form an overwintering and pupation chamber, approx. 40-65 cm above the base of the cane, after making another u-turn so their heads were once again facing up. Cane infestation peaked in early to mid July in both years. Parasitism of larvae occurred primarily near the cane tip. In the two years, parasitism reached 47-100%. Several species of endo- and ecto-parasites

were found. Parasitism intensity peaked in late July to early August. Susceptibility to horntail infestation varied among seventeen summer- and ten fall-bearing raspberry cultivars. Royalty, Cascade Dawn, and Cascade Delight were the least susceptible or attractive summer-bearing varieties; while Polana, Caroline, and Summit were the least infested fall-bearers in both years. Information on raspberry horntail life history, parasitism, and raspberry cultivar susceptibility will guide development of pest management strategies and tactics.

EFFECTS OF TWO KEY ORCHARD FUNGICIDES ON THE NATURAL ENEMY *DERAEOCORIS BREVIS* (UHLER) (HEMIPTERA: MIRIDAE)

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This study focused on lethal and sublethal effects of Kumulus DF [sulfur] and a mixture of Kocide 3000 [copper hydroxide] and Manzate Pro Stick [mixture of manganese, zinc and ethylenebisdithiocarbamate] tested against adult (males and females) and second instar *Deraeocoris brevis* (Hemiptera: Miridae). Products were tested using concentrations that were equivalent to the high label rate (1x) and 1/10th of that amount (0.1x) dissolved in 100 gallons of water. Kumulus DF appeared to be toxic to nymphs at both rates. The mixture of Kocide 3000 and Manzate Pro Stick caused less toxicity to both nymphs and adults. Longevity of adult males and females was not affected by the materials tested. Survival of treated nymphs to adults was negatively affected by both rates of Kumulus DF. Sex ratio of adults that emerged from treated nymphs was not affected by these treatments.

GROUP TAKE-HOME EXAMS: PROMISE, PITFALLS, AND POSSIBLE SOLUTIONS

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The major learning goals of the Honors College course, "Science as a way of knowing" (UH 290), include *information literacy*, *quantitative and symbolic reasoning*, *critical thinking*, and *cooperative group learning*. In collaboration with librarians and an assessment expert, Anelli developed a comprehensive pedagogy that included library instruction (e.g., databases, types of sources, impact factor, peer-review); in-class analysis and evaluation of primary scientific articles; assignments on current, scholarly literature; and group work. Student performance on group take-home exams served as one measure of achievement of the learning goals. Student responses on peer and self-evaluation forms, pre- and post-course surveys, and course evaluations served as indirect performance measures. Our findings from three semesters indicate that most students prefer take-home exams *vs.* in-class exams because of greater time availability, the "real world" nature of the questions, and the opportunity to network with peers. Students also reported gaining an enhanced ability to conduct literature searches and to critically

analyze scientific papers. Yet despite the promise for enriched student learning that group take-home exams represent, pitfalls occurred. Student complaints focused on group dynamics issues and exam length. Possible solutions to these problems exist and will be explored in our talk. We conclude that group exams represent powerful learning tools, and that instructors can improve student success (in terms of learning, grade earned, and experience they have) by 1) employing strategies that cultivate group work "best practices," 2) adjusting group scores to reflect individual student contributions, and 3) ensuring a suitable mix of individual and group work (particularly graded work).

BELAY® INSECTICIDE, NEW CROP REGISTRATIONS

Mike Ansolabehere

Valent U.S.A. Corporation, 7498 N. Remington Ave. #102, Fresno, CA

Belay® Insecticide received Federal EPA registration in 2010 for use in brassica vegetables, cotton, cranberry (low growing berry, except strawberry), cucurbits, fig, fruiting vegetables, leafy vegetables, peach, pomegranate, soybean, tree nuts (except pistachio) and tuberous and corm vegetables including sweet potato. Registration on these crops is anticipated in early 2011 for CA. Belay is a third generation neonicotinoid insecticide, which contains the active ingredient clothianidin. Clothianidin has lower water solubility and optimal KOC values so it is more available for plant uptake and less prone to leaching than other neonicotinoids. Belay has demonstrated good activity on plant bugs/lygus, stink bugs, aphids, fleahoppers, mealybugs, beetles and grubs and offers suppression of thrips and whiteflies. In general, Belay is more active on plant bugs, stink bugs, beetles and weevils than other neonicotinoids. Belay can be applied foliar at 2.0 to 6.0 fl oz/A with the rate depending on crop, pest and pest pressure. Belay can also be applied at 9.0 to 12.0 fl oz/A to the soil on brassica vegetables, cucurbits, cranberry, fruiting vegetables, leafy vegetables and tuberous and corm vegetables. Belay is formulated as a 2.13 lb ai/gal soluble concentrate and may be applied with ground or aerial application equipment (potato, cotton and soybean only).

MEALYBUGS AND VIRUSES IN WASHINGTON STATE VINEYARDS

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Mealybugs have been identified as primary vectors of grapevine leafroll associated viruses (GLRaVs) in Washington vineyards. The grape mealybug, *Pseudococcus maritimus*, is the predominant species in Washington vineyards and was shown to be a competent vector of GLRaVs in California in 2002. There are nine strains of GLRaV, of which, six were present in Washington state vineyards as of 2007. Different varieties of *Vitis vinifera* are very susceptible to infections of GLRaV, causing a 60% loss in yield in some instances, while varieties of *Vitis labrusca* have latent infections of this disease. In Washington State, many wine and juice grape vineyards are grown in close proximity to each other. We have sampled 'Concord' juice grape vineyards in the Yakima Valley and tested these samples for the presence of all identified strains

of GLRaV as well as other viruses that occur in Washington State, such as Fanleaf and viruses of the Rugose Stem Pitting Complex. Grapevines and any associated Mealybugs will be tested for the presence of these viruses.

LONG-TERM STUDIES OF THREATS TO THE PALILA, AN ENDANGERED FOREST BIRD ON MAUNA KEA, HAWAI'I

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The palila, *Loxioides bailleui*, is one of the last finch-billed species of Hawaiian honeycreepers (Drepandinae), which represent the most spectacular adaptive radiation among songbirds. As a seed specialist, palila feed mainly on the immature seeds of an endemic leguminous tree, māmane, *Sophora chrysophylla*, but an endemic tortricid caterpillar, *Cydia plicata,* is also important in the diet. Palila and their subalpine habitat on Mauna Kea Volcano are threatened by a wide range of invasive species, although palila occur above the present range of mosquito-borne diseases. Introduced browsers have degraded the palila's habitat, and in their shrinking range, invasive grasses and other weeds increase fire risks and an alien fungus may be killing māmane trees. Feral cats depredate about 10 percent of palila nestlings annually, and other introduced mammalian predators threaten the population. Alien and one possibly native species of ichnuemonid wasp parasitize *Cydia* caterpillars, especially at lower elevations. Argentine ants, *Linepithema humile,* and other invasive ant species are encroaching on palila habitat from lower elevations and threaten arthropod communities that support palila and their associated plants. The predaceous yellowjacket, *Vespula pensylvanica*, has invaded palila habitat and may also reduce arthropod prey availability if it becomes abundant. Severe drought affects palila survival and reproduction by reducing the availability of māmane seedpods, and the palila population has been declining sharply since 2003. Removing browsers to restore habitat is legally mandated, but reducing some of the other threats to palila, their habitat, and their arthropod prey could substantially boost prospects for population recovery.

PARASITOIDS AND ECOLOGICAL RISK ASSESSMENT: USING LIFE HISTORY DATA TO PREDICT POPULATION RESPONSES TO PESTICIDES

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Parasitoid wasps are important control agents for a suite of economically important arthropod pests. However, it is well known that hymenoptera in general are highly vulnerable to the effects of chemical pesticides, and so represent an opportunity to better understand the compatibility of biological and chemical control of pests. Closely related species are often used in risk assessment trail in order to better assess the effects of different chemical toxicants on hymenoptera. Most of these tests focus on acute toxicity, with few exploring longer-term population outcomes. Here, using a simple mathematical framework, we quantify the relative vulnerability of a suite of parasitoid species to the sublethal effects of a toxicant acting on fecundity. Using an equation that describes a critical extinction threshold, we calculate levels of reduction in fecundity above which parasitoid species important for biological control are driven to local extinction. We apply this framework to four economically important braconid biological control agents and find that threshold levels vary widely among them. Our findings imply that caution should be exercised in assuming species even within the same functional guild may be used as surrogate species for one another.

Prionus californicus (COLEOPTERA: CERAMBYCIDAE), A MAJOR PEST OF HOPS: USE OF ITS SEX PHEROMONE FOR MONITORING, MASS TRAPPING, AND MATING DISRUPTION

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The large ceramybid beetle *Prionus californicus* Motschulsky (Coleoptera: Cerambycidae) is an endemic species that is a major pest of hops in the northwestern United States. It also can be a serious pest of many species of deciduous trees, including stone fruits and oaks. We recently identified the female-produced sex pheromone of this beetle as (3*R*,5*S*)-3,5-dimethyldodecanoic acid. This compound, as the pure enantiomer or as a mixture with its other three possible stereoisomers, is highly attractive to male beetles. This fact, coupled with a number of other biological and economic factors (e.g., the adult beetles are only active for a few weeks each year, life cycle is 2-3 years, males are attracted from long distances to small doses of pheromone, hops are a high value perennial crop, the pheromone can be made in large quantities at an affordable price), suggests that pheromone-based control of the beetle might be feasible. Here we summarize the results of preliminary field experiments that evaluated the potential for using the synthetic pheromone to manage infestations of *P. californicus* in commercial hop yards by mass trapping or mating disruption. Our results suggested that mass trapping may be effective in reducing mating success of the females: in field trials, positioning surrogate females (sentinel traps baited with a low dose of pheromone) within a square of eight pheromone-baited traps resulted in an 88% reduction in the number of males that reached the sentinel traps when compared to sentinel traps that were surrounded by traps baited with blank lures. Similarly, surrogate females that were within a square of pheromone lures (no traps) were reached by 84% fewer males than surrogate females surrounded by blank lures, suggesting that mating disruption also may be effective. A mark-recapture experiment indicated that male *P. californicus* were attracted to traps baited with 1 mg of pheromone from as far away as 585 m. Overall, these

studies indicate that 3,5-dimethyldodecanoic acid has considerable potential for managing *P. californicus* in hops, and perhaps in other crops in which it is a pest.

SPRING STUBBLE INSECTICIDE APPLICATIONS IN ALFALFA AS A WAY OF MANAGING THE THREECORNERED ALFALFA TREE HOPPER, *SPISSISTILUS FESTINUS*

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In 2010 a 2-year study was initiated to evaluate the feasibility of a single application of Cyfluthrin (32.4 g [AI]/ha) made to early spring "stubble" alfalfa (*Medicago sativa* L.) to mitigate season-long populations of Threecornered alfalfa tree hopper , *Spissistilus festinus* Say as part of a reduced pesticide application program. Three replicated forage alfalfa fields (≈12.14 ha each) contiguous with irrigation drainage ditches were used to establish split plot comparisons. A single directed "stubble" application of Cyfluthrin was made immediately after the first alfalfa cutting was removed from the field. Bi-weekly sampling of fields began in May to determine the effect of treatments on population dynamics of TCAH and the potato leafhopper (complex) which includes the Potato leafhopper, *Empoasca fabae* (Harris), the Garden leafhopper, *Empoasca Solana* DeLong, and the Mexican leafhopper, *Empoasca mexera* Ross and Moore. Each sampling date consisted of sweep-net, beat-net and mean alfalfa stem height. Alfalfa forage quantity and quality was determined with bail counts, weights and tissue samples taken on harvest dates. No treatment effect was observed between either Threecornered alfalfa tree hopper ($f = 4.12$, $df = 69$, $P = 0.42$) or Potato leafhopper populations ($f = 4.12$, $df = 69$, $P = 0.49$).

SHOCK AND AWE: A NARRATIVE HISTORY OF SPOTTED WING DROSOPHILA IN WEST COAST SWEET CHERRIES

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Among tree fruits, sweet cherries are a high-risk crop for spotted wing drosophila attack, and the discovery and spread of this pest has caused a shock wave through the west coast cherry production region. The pattern in the past three years has been that of a late-season detection, followed by an intensive detection and monitoring program, followed by the realization that this species was widespread and in very high populations. This pattern has been repeated, with variations, from California to British Columbia. The year following detection has been a year characterized by high levels of crop damage, before growers have re-adjusted their attitudes and practices to handle this new pest; by the second year post-invasion, programs have been altered sufficiently to provide high levels of crop protection. In the immediate future, growers will likely over-spray until better information is available on thresholds, efficacy, and residual control. Concerns about crop loss, quarantines and exports have made accurate information on

damage difficult to gather and assess, and hindered the dissemination of much-needed information.

CASE HISTORY OF THE IMPACTS AND CONTROL OF INVASIVE WASPS IN NEW ZEALAND

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Six species of Vespidae have established in New Zealand, and three of these are considered invasive species; *Vespula vulgaris*, *V. germanica* and *Polistes chinensis antennalis*. *Vespula vulgaris* in particular has become extremely abundant and causes a range of impacts in natural ecosystems. As a generalist predator it feeds on a wide range of native invertebrates, but it also severely depletes the honeydew resource for about 4 months of the year. By disrupting the addition of honeydew to the forest floor, wasps can alter multiple components of the soil decomposer subsystem, including decreasing litter decomposition and altering soil carbon sequestration and nutrient capital. Wasps are also implicated in the long-term decline of several common species of native birds. In some habitats, *V. germanica* and *P. chinensis antennalis* are also abundant. A range of control strategies have been tried against these three species of wasp. Toxic baiting has proved very successful against *Vespula*, but it is not an option for *Polistes* as they do not scavenge for protein. Direct poisoning of nests is an option, but this does not usually achieve control at the population level. Neither does trapping. There have also been several attempts using biological control, but to date none of these has been successful. Integrated management of *Vespula* and other predators has been undertaken in Nelson Lakes National Park for the last decade, but many challenges remain.

SPOTTED WING DROSOPHILA HOST SUITABILITY INDEX FOR SEVERAL CALIFORNIA FRESH FRUITS

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Spotted wing drosophila (SWD), *Drosophila suzukii*, was first identified in central California in 2009 and now populates regions of key fruit production, as well as coastal regions surrounding Pacific port terminals. The discriminatory nature of *D. suzukii* oviposition needs to be established on undamaged ripe fruit across a range of potential hosts, which include strawberries, raspberries, cherries, blackberries, blueberries, and grapes. With insight into this critical piece of SWD biology lacking, implementation of effective pre- and post-harvest control measures have been obstructed. Here, we report a postharvest host suitability index for the SWD based on the integration of a series of bioassays: preferential flight response to fruit-derived olfactory cues, oviposition rates on fruit, and developmental success in fruit-based media

THE SAMOAN SWALLOWTAIL BUTTERFLY *PAPILIO GODEFFROYI* IN THE SAMOAN ARCHIPELAGO: STATUS AND CONSERVATION

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The Samoan Swallowtail butterfly or pepe ae (*Papilio godeffroyi)* is endemic to the Samoan Archipelago in the South Pacific. The last confirmed sighting from the islands of Upolu and Savai'i (Independent State of Samoa) was in 1979. Recent intensive searches have failed to find the butterfly on either of these islands. It is currently only known from the island of Tutuila in American Samoa, where it is uncommon but widespread. The range of the Samoan Swallowtail is now only found within around 5% of its original range, and the species has recently been submitted to the IUCN Red List as critically endangered. We report on the current distribution and status of the Samoan Swallowtail and its host plant talafalu (*Micromelum minutum*) and summarise efforts to protect the species and its habitat.

DUPONCHELIA FOVEALIS, A RECENT PEST INTRODUCTION TO THE U.S. AND A SIGNIFICANT PEST FOR ORNAMENTAL PLANT PRODUCTION

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Duponchelia fovealis is a known pest of peppers in Europe and has been on the APHIS watch list for quite a while. It originates from the Mediterranean region and the Canary Islands, and it is also known to occur in Africa and Asia Minor. It feeds on a wide range of plants including many vegetables and herbs, and ornamentals such as anemone, anthurium, begonia, cyclamen, gerbera, kalanchoe, limonium, and rose varieties. Larvae are cryptic and tend to stay near the soil line in potted plants feeding on the main stem, but they can also be found deep in potting media. Interceptions of this pest have been common in the US, but recently, an established population was observed in San Diego County California. Pheromone trapping by APHIS and the California Department of Food and Agriculture (CDFA) demonstrated that the insect had spread widely in California to more than 20 counties and to more than ten other states. Based on these surveys and on the moth's biology, the CDFA decided not to pursue any control or containment activities. Unfortunately, the moth now poses significant threat to both agriculture and ornamental plant production facilities. We have observed economic damage and significant populations of this moth on begonia, poinsettia, gerbera, and various succulents including many varieties of kalanchoe in San Diego County California. Information will be presented that outlines the challenges faced in trying to control heavy populations of this pest.

USE OF BMPS AND IPM IN THE FACE OF INVASIVE PESTS IN CALIFORNIA

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A significant challenge that we face as extension specialists is to develop Best Management Practices (BMP) that uses Integrated Pest Management (IPM) in ornamental plant production when faced with serious invasive pests. Some growers are forced to apply mandated treatment applications that may disrupt the concept of a BMP or the use of beneficials in an IPM program.
A set of production guidelines known as Best Management Practices are usually voluntary and their goal is to minimize negative effects on the environment. BMP considerations for ornamental plant producers include water management, nutrient management, media management, plant selection, pesticide use and storage, pest management, organic and inorganic waste management, and energy conservation. Nursery plant producers' intent is to maximize outputs and profits, and BMPs are employed to minimize the inputs so that excesses are not leached or wasted into the environment. They are especially prevalent when discussing water management in nursery production. IPM is encouraged in most BMPs because they tend to rely on a more natural approach to plant growth with little pesticide and fertilizer inputs, and the reliance on beneficials and biologicals.

IPM has many definitions, but it is commonly referred to as the use of all methods of pest control except synthetic pesticides. Some like the EPA have defined it to include the 'judicious use of pesticides'. Clearly though, the intent is to minimize or reduce pesticide use. Indeed, many of the funding programs that originate from government sources like the EPA now encourage the submission of proposals that have the goal of reducing pesticide use. The purpose of the Pesticide Environmental Stewardship Program (PESP) Grants for instance is to provide funds for research, education, and demonstration to reduce the risk and use of pesticides, in both agricultural and non-agricultural settings. The Pest Management Alliance Grants from the California Department of Pesticide Regulation also encourages the submission of proposals where the goal is demonstration of methods that reduce pesticide use in agricultural and non-agricultural settings.

Unfortunately, pesticide use mandated by government agencies to stop the movement of invasive pests is juxtaposed to the goals of reducing pesticide use. In fact, in some cases the total amount of pesticides used against an invasive pest is increased beyond what is normal for production nurseries. In addition, mandated pesticide applications are not typically compatible with beneficials and tend to disrupt natural control of organisms that are common at low levels in production such as aphids and mites. The result is the need for further treatment applications.
In southern California, the ornamental plant production industry faces several mandatory treatment applications depending on a number of factors including whether the pest is present on the grounds or whether the nursery is in a quarantine area. There are mandatory treatments for the red imported fire ant, the glassy-winged sharpshooter, the Diaprepes root weevil, and the light brown apple moth. Each of the examples above require a signed Compliance Agreement with the California Department of Food and Agriculture and pesticide applications must be observed by regulatory personnel.

Therefore, the development of BMPs for most ornamental plant production facilities should be stringent enough to significantly reduce the risk of moving serious pests that may have a significant impact on agriculture or the environment at its final destination. The use of broad-spectrum pesticides may be an effective way to minimize pesticide use under some of these circumstances. These issues and more will be discussed.

ARGENTINE ANT SPREAD AND MANAGEMENT ON SANTA CRUZ ISLAND

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Argentine ants (*Linepithema humile*) are a highly invasive species that out-compete native ants and disrupt mutually beneficial interactions between plants and native ants. First discovered on Santa Cruz Island (SCI) in 1996 at two locations, surveys conducted in 1997 estimated the infestations at 1.5 and 0.05 km^2 respectively. Thereafter, Argentine ants established at two additional locations in the island's central watershed. In Fall 2010, managers delimited the four infestations, now estimated to cover 2.28 km^2. Of the original infestations, one has expanded at 10-40 m per year to cover 2.1 km^2; the other has contracted at 0-9 m per year and now covers 0.08 km^2. That range constriction may have occurred in part due to demobilization of human initializations, low quality habitat or unfavorable climatic conditions. Observations indicate that Argentine ant density may be higher in oak woodlands, riparian areas, and chaparral, and lower in fennel/annual grass and coastal sage scrub. If food resources are limited in fennel/annual grass and coastal sage scrub and these habitat types comprise 77% of the infested areas, then current Argentine ant spread may be slowed by resource limitations. A greater percentage of oak woodlands, riparian areas, and chaparral occurs within the 200 m buffer of the current infestation, suggesting that rate of spread could increase in the next 5 years. Managers are working with researchers and ant control experts to identify baiting regimes effective in eliminating colonies. They are increasing island biosecurity to ensure that Argentine ants do not re-invade from the California mainland.

AN APIARY-WIDE STUDY OF SUB-LETHAL PESTICIDE EFFECTS ON HONEY BEE (*APIS MELLIFERA*) COLONY HEALTH

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The European honey bee, *Apis mellifera*, is critical for pollination of many agricultural crops. High colony losses have been reported in recent years, possibly due to a number of interacting factors including pesticide exposure, parasitic mites, microsporidian pathogens, and others. Previous work has shown that exposure to pesticide residues in brood comb has detrimental effects on honey bee development, weight at emergence and adult lifespan. This study focuses on how such effects impact honey bee health on an apiary-wide scale. In April 2010, honey bee colonies were established in forty hives, twenty of which contained brood comb with accumulated high levels of pesticide residues and twenty that contained brood comb with low

levels of pesticide residues. Colonies were monitored throughout the season for differences in queen acceptance, brood surface area, adult population, hygienic behavior, *Varroa* and tracheal mite levels, *Nosema* spore counts, queen cell production and honey yield. Results from the 2010 field season indicated increased brood production in treatment (high residue) hives compared to control colonies, despite no detectable differences in adult bee population. These findings suggest that increased brood production may be compensatory for decreased adult longevity in bees reared in high pesticide residue brood combs. Other potential differences in colony health and population demographics will be monitored following the winter of 2010 and during the 2011 field season.

MANAGEMENT OF SPOTTED WING DROSOPHILA IN BERRIES

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The spotted wing Drosophila (SWD), *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) is an invasive pest of small fruit crops. This pest was first found in California in 2008 and its presence confirmed in Oregon and Washington in 2009. Unlike other members of the Drosophilidae family, this vinegar fly is able to oviposit into and damage ripe and ripening fruit making it unmarketable. Because this is a new pest in our region, it is necessary to identify insecticides for use in conventional and organic production systems to manage this insect effectively. We are developing integrated management practices to control this pest in the region. We will present data from field and laboratory experiments to identify the most efficacious conventional and organic products for SWD management. We will also discuss cultural controls that growers can implement to help mitigate fly populations including fruit sanitation and shortening harvest intervals.

RELEASE OF STERILE CODLING MOTH TO CHALLENGE MATING DISRUPTION TECHNOLOGIES IN COMMERCIAL ORCHARDS

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Finding a method to compare mating disruption technologies that provides a consistent and repeatable result is difficult. Factors confounding mating disruption research include enough area to accommodate large replicated plots, an even distribution codling moth populations, and grower willingness to accommodate an untreated control. Evaluating pheromone treatments using fruit injury or capture of moths in traps often provide insufficient data to assess treatment effects, that is numbers are low and highly variable. By using the release of sterile moths to challenge pheromone treatments we were able to conduct trials in orchards with very low codling moth pressure. In these situations we were able to convince growers to leave portions of their

orchard untreated (with pheromone) giving us a true non-pheromone control. Further, we were able to replicate the entire study across several sites and the release of sterile moths eliminated one of the most important sources of variance, background pressure gradients. Three mating disruption technologies were evaluated: Isomate® CM FLEX (320/acre), Isomate® CM RING (32/acre), and CheckMate Puffer CM (1/acre). Sterile moths were released in the center of each treatment weekly. Recovery of sterile moths was evaluated in traps baited with a female mimic pheromone lure (0.1 mg). All three technologies provided a high level of trap shutdown, with little apparent difference between the treatments. The average trap shutdown relative to the untreated control across the three test sites was; 94.9% for Isomate® CM FLEX, 93.7% for the CheckMate Puffer CM, and 92.8% for the Isomate® CM RING.

SCOLYTINAE (COLYOPTERA: CURCULIONIDAE) ATTACKING COFFEE BERRIES IN HAWAI'I

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Coffee in Hawaii is grown from sea level to 762 meters elevation, and the largest contiguous area of production is in the North and South Kona district of the Island of Hawaii. There are 830 coffee farms recorded in the state of Hawaii with 6,300 acres harvested, 790 of which are located on the island of Hawaii with 2,900 acres harvested annually. Forty coffee farms are located on other major Hawaiian islands (Honolulu, Kauai and Maui), with 3,400 acres harvested and these contribute significantly to the total value of Hawaii's coffee production. The black twig borer, *Xylosandrus compactus,* is an ambrosia beetle that has been reported in Hawaii since 1960 and attacks branches of more than 200 plant species, including coffee. This beetle was found recently for the first time boring coffee berries. Female beetle entry holes were observed close to the blossom area or the side of the berry. Beetles reached the endosperm and caused damage without making galleries or ovipositing. The coffee berry borer, *Hypothenemus hampei* is the most aggressive coffee pest in the world and reported in Hawaii in August, 2010, from the South Kona area. Comparisons of the biology, behavior and management of these beetles are discussed.

NAVEL ORANGEWORM: A MAJOR PEST IN MANY CROPS

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The navel orangeworm, *Amyelois transitella* (Walker), is a generalist that attacks mature fruit of a wide variety of horticultural crops. It is an important economic pests of almonds, pistachio, and walnuts, each of which are among the 20 most valuable crops in California and are planted on >100,000 acres; and on dried figs, which is the 63rd most valuable crop and is planted on

<10,000 acres. We will compare abundance, susceptibility, and pest management options between these crops.

BEHAVIORAL RESPONSES OF POTATO PSYLLID TO POTATO GERMPLASM AND TRANSMISSION OF *CANDIDATUS LIBERIBACTER PSYLLAUROUS*

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The potato psyllid, *Bactericera cockerelli* (Sulc) (Hemiptera: Triozidae), is a major pest of potatoes that can cause yield loss by direct feeding on crop plants and by vectoring a bacterial pathogen, *Candidatus* Liberibacter psyllaurous (a.k.a. *Candidatus* Liberibacter solanacearum). In recent years, there have been no studies regarding resistance of potato to the potato psyllid or the bacterial pathogen that the psyllid vectors. Thus, the objectives of this study were to determine the effects of potato germplasm on adult potato psyllid behavior and transmission of *Ca.* L. psyllaurous. Potato varieties and breeding clones tested included 'Atlantic', 'GemStar Russet', '463-4', 'P2-3', 'P2-4', 'Etb 5-31-3', 'Etb 6-21-3', 'Etb 6-21-5', 'A00ETB12-2', 'A00ETB12-3', 'A05379-69', 'A05379-211', 'Russet Norkotah', 'King Harry', 'NY138', 'BTX1749-1W/Y', 'NDTX731-1R', 'TX05249-10W', 'ATX85404-8W', 'ATTX98500-3PW/Y', 'BTX1544-2W/Y', and 'AOTX95295-1W'. Plant genotype significantly impacted the occurrence and duration of psyllid probing, the duration of psyllid cleaning, resting, and the amount of time psyllids spent off the potato leaflet as well as transmission of *Ca.* L. psyllaurous. For the potato genotypes in which there were significant decreases in transmission compared to controls, there was often an unclear relationship between the occurrences and duration of behaviors and subsequent bacterial transmission. We discuss our results for an integrated pest management program for the potato psyllid and *Ca.* L. psyllaurous control on potatoes.

ANALYSIS OF VERTICAL DISTRIBUTIONS AND EFFECTIVE FLIGHT LAYERS OF INSECTS: 3D SIMULATION OF FLYING INSECTS AND CATCH AT TRAP HEIGHTS

John A. Byers

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The *effective attraction radius* (EAR) of a pheromone-baited trap was defined as the radius of a sphere that would intercept the same number of flying insects as the attractant catches. The EAR is transformed into a circular EAR_c for use in two-dimensional encounter rate models of mass trapping and mating disruption using semiochemicals. However, the EAR_c equation requires estimation of the effective flight layer (F_L), a uniform density layer equivalent to a normal

density distribution where insects fly in search of mates/food/habitat, and was shown previously to equal $SD \cdot \sqrt{2 \cdot \pi}$. The work here calculates the mean and standard deviation (*SD*) of flight height of over 100 insect species from their catches on trap heights reported in the literature in order to estimate F_L for each species. In addition, the vertical catch distributions were compared to a normal distribution and analyzed for skew and kurtosis. Simulations of flying insects in three dimensions (3D) were performed with an algorithm that caused individuals to roam freely at random but such that the population distributed according to a normal distribution of specified mean and *SD*. Within this 3D arena, spherical traps were placed at various heights to determine the effects on catch and *SD*. The results indicate that data from many field studies should provide good estimates of the true population mean height and *SD* of flight. The EAR and $SD/F_L/EAR_c$ are important parameters in practical models of control using semiochemicals, and for determining whether a weak or incomplete pheromone blend has been identified with low potential for applied measures.

POTENTIAL OF MACARANGA TANARIUS AS A BANKER PLANT FOR ANTHOCORIDS TO CONTROL THRIPS IN ORCHIDS

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In the course of a survey of flowering plants on the Big Island for potential banker plants for anthocorids, we have discovered that the tree, *Macaranga tanarius* (blush macaranga), blooms year round and is a continuous source of large numbers of the minute pirate bug, *Orius persequens* (White), and smaller numbers of the anthocorid *Montandoniola confusa* (Streite & Matocq). *Orius* is a pollinator of *Macaranga tanarius,* which is an unusual and interesting ecological role for a predacious insect species. Both of these anthocorid species are potential biological control agents for thrips in ornamental greenhouses and shadehouses. Blush macaranga will grow and bloom in pots which could be moved around as needed to bring in predators for thrips control. This plant can also be used as an attractive addition in landscape plantings with the dual purpose of enhancing biological control of insect pests. Trees reach up to 40 feet in height and grow at elevations below 1000 feet. In addition to the anthocorids, large numbers of a mirid plant bug species were always present on sample trees, while adults and larvae of the tubuliferous thrips, *Dolichothrips nesius* (Stannard) were present at certain times of the year. These thrips are not found in orchids and we have been unable to establish them on orchids in cage experiments. This suggests that use of blush macaranga is not likely to introduce pest species of thrips into orchid plantings.

STRONG EVIDENCE FOR MEDFLY CALIFORNIA RESIDENCY: WHAT SHOULD BE DONE?

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The broad purpose of this presentation is to re-visit the conclusions I reached in 20 years ago that the Mediterranean fruit fly is established in California. The talk will be divided into three parts. First, using a series of maps indicating the locations of medfly finds I will present the 35 year history of medfly finds in southern California starting in Santa Monica and 1975 through one of the most recent finds, again in Santa Monica in 2009. Second, I will bring the updated data on medfly captures to bear on the questions regarding medfly establishment and show that they support the hypothesis that the medfly is still established in the state. Third, I will discuss the implications of this conclusion including the need to develop new paradigms for dealing with invasive species in general tephritids in particular.

THE COMPLEX IMPLEMENTATION OF AN IPM PROGRAM FOR FRESH MARKET TOMATOES

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IPM programs for the commercial production of tomatoes have become increasingly more complex. New classes of insecticides, which target specific insects, have restrictions on the number of applications. Additionally, industry has a goal to avoid pesticide resistance by complying with the IRAC classification guidelines. Growers and PCAs have to consider the targeted pests, the available insecticides, the number of applications, the impact on beneficial insects, and the classification of all insecticides used within the IPM program. Another emphasis is incorporating reduced risk materials into the IPM program, which provides added benefits to the material handlers, environment, consumers, and complies with the Food Quality Protection Act. The long term goal is to provide sustainable control of insect pests using an economically viable approach. To take all of this into consideration when designing an IPM program can be difficult. The approach we use has proven effective. From trials designed to identify new efficacious materials, the most promising compounds are introduced into an IPM program. The results are compared to a 'chemical standard' strategy, and subjected to an economic analysis. Recent examples of the design, the field trials to evaluate the strategy, and the economic analyses of such IPM programs are discussed.

ACTIVITY PROFILES OF NEONICOTINOIDS IN CROPS AND THEIR RELEVANCE TO PEST CONTROL

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The duration that an insecticide is active in a crop in terms of lethal and sub-lethal effects on insect populations is a critical concept in pest management that has been poorly developed. Application rates, the timing and spacing of applications, as well as the choice of applications could all be influenced by more reliable information on the titers and persistence of systemic insecticides in crops. The advantage of directly measuring insecticide concentrations within a

plant is that evaluation criteria do not necessarily depend on measuring the impact on target populations, but instead rely on identifying temporal and spatial profiles of insecticides within plants. If these direct measurements can be tied to pest densities in the field or possibly to laboratory bioassay data that provide information on effective doses, then pest management decisions can be refined based on more direct and accurate measurements of what a systemic insecticide is doing in a plant. We will present data on the titers of two neonicotinoid insecticides in both annual and perennial crops and attempt to relate this data to the control of specific key pest species including *Bemisia tabaci* and *Homalodisca coagulata*.

MANAGEMENT OF APHIDS, PLANT BUGS AND WHITEFLIES ON WESTERN U.S. COTTON WITH DOW AGROSCIENCES' SULFOXAFLOR INSECTICIDE

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Peter C. Ellsworth[2], Larry Godfrey[3], and David L. Kerns[4]

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Cotton aphid, *Aphis gossypii* Glover, western tarnished plant bug, *Lygus hesperus* Knight, and sweetpotato whitefly, *Bemisia tabaci* (Gennadius) are important sap-feeding insects that reduce yield and quality of western cotton, *Gossypium hirsutum* L. Sulfoxaflor is the first member of the novel sulfoximine class of insecticides lined up for commercialization. Sulfoxaflor was discovered by and is proprietary to Dow AgroSciences. The objective of this presentation is to provide an overview of the efficacy of sulfoxaflor to manage cotton aphids, plant bugs and whiteflies across three western states of the U.S. cotton belt from 2008 until 2010. Results demonstrate the efficacy of sulfoxaflor at low rates, its fast activity and extended residual control when managing cotton aphids and plant bugs compared to commercial standards. It provided whitefly suppression and control at higher rates. In addition, results showed that sulfoxaflor is effective on insect populations resistant to a variety of other insecticides. No cross resistance between sulfoxaflor and neonicotinoids has been detected. These data suggest that sulfoxaflor will occupy a unique position and will be a valuable tool for the management of sucking pests of cotton production. Once registered, sulfoxaflor will be commercialized as Transform™ insecticide (50% WG formulation) in U.S. cotton. A registration decision on U.S. cotton is anticipated in 2012.

PROMINENT PROFESSORS YOUTHFUL BEGINNINGS: THE GRADUATE WORK OF BIG NAMES IN IPM

Meredith Cenzer

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Although we are all aware of the contributions to IPM made by well-known researchers, where their research began is often concealed in the mists of time. This talk will discuss the graduate research of prominent IPM professors currently working in the state of California, selected from those who received ESA awards for excellence in IPM, Extension, or Horticulture, as well as the Recognition Award, in the past 3 years. By examining the early career contributions of well-established scientists, we can see how the field of IPM has been changed by their work. In addition, this talk should inspire current graduate students by examining how a career in this field can develop, and how graduate work sets the tone for their own future research.
Prominent researchers to be included in this talk are: Frank Zalom (UC Davis), recipient of the 2010 Excellence in IPM award; Michael Parrella (UC Davis), recipient of the 2010 Distinguished Achievement Award in Horticulture; Larry Godfrey (UC Davis), recipient of the 2010 Distinguished Achievement Award in Extension; Elizabeth Grafton-Cardwell (UC Riverside), recipient of the 2010 Recognition Award in Entomology; Timothy Paine (UC Riverside), recipient of the 2009 Distinguished Achievement Award in Horticulture; and Jocelyn G. Millar (UC Riverside), recipient of the 2008 Excellence in IPM Award. The current work of these scientists spans from the mediating effect of chemicals on pest behavior to the influence of urban insect communities on woody ornamental pests, in systems from flowers to fruit trees. This talk will summarize their graduate work, discuss its influence on modern IPM, and contrast it with their current research.

VIRTUAL WEATHER STATIONS IN WSU-DAS

Ute Chambers, Vincent P. Jones and Gary Grove

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The WSU Decision Aid System (DAS) uses WSU-AgWeatherNet (AWN) environmental data and site-specific forecasts provided by NOAA to run insect and disease models. Even though AWN has 132 monitoring sites, there are still areas with tree fruit production that are underserved. We are currently evaluating the possibility of using "virtual weather stations" in DAS that are based on NOAA forecasts alone.

In 2009 and 2010, we calculated degree-day (DD) accumulations from AWN temperature data and from 1-day NOAA forecasts using parameters for codling moth (CM) and six other insects. Comparisons showed a strong linear relationship the two data sources. However, slope and intercept varied, resulting in significant differences in predictions, which were correctable using linear regression. For example, using % CM egg hatch the mean deviation using the raw data was 4.4 ± 0.1 days, and 1.6 ± 0.04 days when corrected using regression. In addition, because NOAA uses AWN data to make their forecasts, we compared NOAA forecast data with data from 48 independent weather stations. For CM predictions, the mean deviation between the NOAA raw data and the independent stations averaged 5.3 ± 0.3 days, and the difference using

the corrected data was 1.4 ± 0.1 days. Importantly, the empirical relationship between the DD accumulations from AWN and NOAA did not change between 2009 and 2010 allowing the use of the same correction method once it is determined for each location. This suggests that virtual weather stations in DAS are possible.

MARRONE BIO INNOVATIONS INSECT MANAGEMENT UPDATE

Lisa Chanbusarakum[1]

[1]Marrone Bio Innovations, Davis, CA

This presentation will provide an update on recent developments in the insect management product portfolio for the crops business of Marrone Bio Innovations.

LABORATORY EVALUATION OF THE CHEMOSTERILANT LUFENURON AGAINST *CERATITIS CAPITATA, BACTROCERA DORSALIS, B. CUCURBITAE*, AND *B. LATIFRONS*

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Four species of tephritid fruit flies in Hawaii, *Ceratitis capitata* Wiedemann, *Bactrocera dorsalis* Hendel, *B. cucurbitae* Coquillett, and *B. latifrons* Hendel were evaluated for toxic, developmental and physiological responses to the chemosterilant lufenuorn incorporated in an agar adult diet and a liquid larval diet. No significant mortality of the first three species except *B. latifrons* was observed after their exposure up to 50 ppm of lufenuorn in the agar adult diet while the effect of lufenuron on fertility is dosage dependent. Fertility of *C. capitata* adults fed on 50 ppm lufenuron fortified diet during age of 7-12 d was approximately 46% of the no lufenuron control. The fertility of *C. capitata* remained consistently lower for up to 14 days old. Fertility of *C. capitata* adults from 10 ppm lufenuron fortified diet was fluctuated between 28% and 87% among 7-12 d. No significant effect on fecundity was observed. Fertility of *B. dorsalis* and *B. latifrons* adults fed on 50 ppm lufenuron incorporated diet was about 46% and 61% of the control, respectively, while fecundity was not affected. Both fertility and fecundity of *B. cucurbitae* adults were not affected by lufenuron. Various performances of the larvae of the first three species fed on liquid larval diet with $\leq$0.1 ppm of lufenuron was evaluated. Pupal recovery, pupal weight, adult emergence, adult flier, mating, egg hatch, and egg production were significantly decreased in *C. capitata* while pupal recovery, larval duration, adult emergence, and egg production were affected in *B. dorsalis*. No effect of lufenuron on *B. cucurbitae* larvae was observed. In summary, lufenuron showed significant developmental and physiological effects on larvae and adults of *C. capitata* and *B. dorsalis*. Lufenuron is a potential agent for the management and control of *C. capitata* and *B. dorsalis*.

BAYER CROPSCIENCE INSECT MANAGEMENT UPDATE

Dean Christie

[1]Bayer CropScience, Spokane, WA

This presentation will provide an update on recent developments in the insect management product portfolio for the crops business of Bayer CropScience

MORPHOLOGICAL FEATURES IN OOGENESIS OF ORIENTAL FRUIT FLY IN RELATION TO PHYSIOLOGICAL AGE IN FIELD POPULATIONS

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Key morphological features in ovarian development such as ovarian index, egg load, and follicular relics were examined as grading methods to determine physiological age of female oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae). Laboratory-reared *B. dorsalis* females of known chronological and physiological ages were used for these assessments. Morphological age grading methods that offer simple two-category prediction to determine female's parity status were found to provide high-accuracy classifications. Significant differences were found in the ovarian index and egg load between females at each oogenesis stage. The presence of follicular relics with distinct morphological features provides a reliable identification tool to determine the physiological state of wild strain female oriental fruit fly. We discuss applications of this technique to identify the physiological age of female fruit flies in their natural habitat.

THIAMETHOXAM AND CYANTRANILIPROLE SOIL APPLICATIONS: A NOVEL BROAD SPECTRUM AT-PLANTING INSECTICIDE FOR POTATO PRODUCTION

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Thiamethoxam is a second generation neonicotinoid insecticide (IRAC group 6) and cyantraniliprole is a second generation diamide insecticide (IRAC group 28). A combination product is being developed by Syngenta Crop Protection, LLC, for use in several field and vegetable crops, including potatoes. Efficacy results and biological attributes will be presented for soil applications of this product in potatoes including pest spectrum, length of control, and implications for integrated pest management.

SPOTTED WING DROSOPHILA TRAP DESIGN AND ADULT FLY SEASONAL DISTRIBUTION

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Spotted Wing Drosophila (*Drosophila suzukii*) was first noted as a problem in sweet cherries in California in May, 2009. It has since spread across the Western United States from California to British Columbia. Many different liquid trap designs and some sticky trap designs for monitoring adult flies have been tested and will be reported upon. Currently, we have standardized our trap design using inexpensive 0.95 liter (one quart) white plastic traps ("deli" style) in which sixteen 4.8 mm (3/16 in) holes have been drilled around the circumference of the upper portion of the container. Two smaller holes are drilled to hold a wire for easier placement in the tree. Traps are hung 0.9 to 1.5 m (3 to 5 feet) from ground level in the lower canopy of the tree in the shade. Many bait formulations have been tried and these will be discussed. Our standard bait formulation currently is 25.4 mm (one in) of apple cider vinegar with un-scented detergent that is changed weekly. This bait is efficacious, inexpensive and easy to retrieve SWD from for identification. Trap contents are examined for the presence of male SWD, female SWD and other Drosophila. Seasonal adult fly catches vary through the year with low populations during the winter (January-March) and often in mid-summer (August). Trap counts begin rising in April and reach a peak during harvest (May-June). A second peak occurs during the fall (October-November). Trap catches vary sufficiently from orchard to orchard that individual orchard sampling is necessary and a minimum of four traps is recommended per block.

A NEW APPROACH FOR THE DETECTION AND MONITORING OF THE COMMON BED BUG *Cimex lectularius*

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A new era of bed bug detection is at hand. Unlike the current screening methods including visual inspection, traps, and scent detection, DNA analysis can provide definitive results. Orkin, in partnership with Research Associates Laboratory, is using forensic DNA technology to detect bed bug infestations in both commercial and residential properties. DNA detection of bed bugs is a relatively simple and cost effective process that can be completed quickly. A designated test area is swabbed to collect any potential bed bug related material, such as feces, exuvia, or other residues. The swab is analyzed in the laboratory using Real-Time Quantitative PCR technology with a 99.9% accuracy rate. Results are reported based on the presence (positive) or absence

(negative) of bed bug DNA. A cleaning and denaturing protocol is employed to remove any residual bed bug DNA, permitting subsequent detection of new activity.

RESTORING A SLICE OF OLD CALIFORNIA: 30 YEARS OF NON-NATIVE SPECIES REMOVAL ON SANTA CRUZ ISLAND

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Some non-native species are highly destructive to native ecosystems and for this reason are often targeted for removal by land managers. Islands, which harbor unique suites of native plants and animals, are particularly vulnerable to disturbance by invaders. Santa Cruz Island (SCI), lying off the coast of Southern California, is jointly owned and managed by The Nature Conservancy and National Park Service. Many harmful non-native species, including ungulates, birds, invertebrates and plants, have been introduced to the Island since it was first settled by people of Old World descent in the mid-1800s. Over the last 30 years, six non-native animal species have been completely removed from the island including feral sheep, free-ranging cattle, feral honeybees, feral pigs, golden eagles and introduced turkeys. In addition, twenty of the more than 150 non-native plant species established on the island are also on the path to complete eradication. The order in which animals were removed had a marked effect on the recovery of the island's vegetation and on populations of native and remaining non-native animals. Successful removal of these animals depended on cooperation from partners, secure funding, unwavering management oversight and the political will to see the projects through to completion. Successful eradication programs on SCI benefited by having agreement from the two land owners to manage the 243 km^2 island as a single ecological unit and by having no resident human population opposed to the removal programs. The focus for the future is on implementing a biosecurity plan to prevent the introduction and establishment of non-native species on Santa Cruz Island.

SYNGENTA CROP PROTECTION INDUSTRY UPDATE: LAWN AND GARDEN INSECTICIDES

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This presentation provides a label update of changes that occurred from January 2010 through March 2011. The presentation covers Lawn and Garden products labeled for production ornamentals, turf, pest control, landscape, and home and garden markets in the United States.

OPTIGARD FLEX, A NEW FRONTIER IN WASP CONTROL FOR PMPS

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Pyrethroids are the most common class insecticides used by Pest Management Professionals for control of stinging wasps. Neonicotinoids are a well know class of insecticides in several markets, but none are labeled for control of ground and structure nesting wasps. Thiamethoxam, the active ingredient in Optigard Flex® was evaluated in eastern and western states and shown to be highly efficacious against adults and larvae in GLP and non-GLP studies. Additionally, spray and foam applications did not appear to repel or irritate adults like a pyrethroid standard.

STATUS OF GRAPE-INFESTING MEALYBUG SPECIES AND ASSOCIATED LEAFROLL VIRUSES IN WINE-PRODUCING REGIONS OF OREGON

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Mealybug species (Heteroptera: Pseudococcidae) were considered minor pests in vineyards in Oregon wine grape production areas. Recent understanding of the role these insects as vectors of the grape leafroll-associated virus complex led to intensive survey efforts in four grape-growing regions across Oregon: Southern Oregon; Willamette Valley; Columbia River Gorge; and Walla Walla Valley. Intensive visual mealybug surveys were conducted monthly from April through October 2010 in eight vineyard sites located in these regions. Cluster mapping suggested that mealybugs spread from infested hotspots or neighboring vineyards. Late-season virus distribution symptoms were compared to mealybug distribution in order to better understand the epidemiology of virus transmission.

Pheromone-baited traps specific to four mealybug species were deployed monthly to help identify species present in Oregon vineyards. Evidence of mealybugs was found in all four Oregon wine grape production areas. Grape mealybug was the only grape-feeding species

present in Oregon vineyards. Observed phenology indicated a minimum of one generation per season. No vine mealybugs (*Planococcus ficus*) were documented on plants or in pheromone traps.

Symptoms identical to those produced by grape leafroll-associated virus were identified visually at the end of the growing season. Enzyme-linked immunosorbent assay (ELISA) and polymerase chain reaction procedures were performed on collected leaves to identify any strains of virus present in symptomatic tissues. Leafroll virus strain 3 was confirmed in Southern Oregon and the Willamette Valley. In the Walla Walla Valley, sampled leaves tested positive in ELISA for at least one virus strain 4-9. No virus was detected in the Columbia River Gorge, despite the sampled vineyard being heavily infested with *P. maritimus*.

GLUPHISIA SEPTENTRIONIS: LIFE HISTORY AND BIOLOGICAL CONTROL OF AN EMERGING PEST IN HYBRID POPLARS

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Gluphisia septentrionis Walker (Lepidoptera: Notodontidae) has caused severe defoliation in the Pacific Northwest hybrid poplar plantations since 2008. Due to the lack of information about *G. septentrionis*, a natural history study was conducted in order to develop a pest management program for this pest. We determined that the complete life cycle of this 5-instars Notodontid can be completed in mid-summer in 36 to 45 days. Our laboratory rearing showed that the 5th instar larva was the most damaging stage, consuming the 90% of a 9 inch^2 leaf in one day. Based on our light trapping, *G. septentrionis* adult flight was determined to be from early-May to late-August. Field observations indicated this pest had two larval generations; one in June and one in September. Our work identified four main natural enemies of *G. septentrionis* within the hybrid poplar system, including: *Trichogramma* sp., *Eulophus orgyiae*, a Tachinid fly and a Pentatomid bug. During 2010, *Trichogramma* sp. and *E. orgyiae* parasitized the 80% of the *G. septentrionis* second generation eggs and the 40% of the *G. septentrionis* established larvae respectively. The second generation of *G. septentrionis* never reached population levels requiring a pesticide application due to the presence of the natural enemies. In 2011, we are planning on evaluating a newly synthesized sex pheromone as a monitoring or control strategy.

IS THERE A ROLE FOR PROFESSIONAL SOCIETIES IN INTERNATIONAL INVASIVE SPECIES RESEARCH?

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Invasive species research is essentially international in nature and scope. Many invasive species exist as metapopulations in complex, open, non-linear systems that are subject to perturbation though natural and anthropogenic mechanisms. The unintended consequences of well-meaning but often independent social, regulatory, economic and political forces converge to create

pathways that favor success of invasive species. Appropriate risk-based control actions can be hampered by these competing interests. All of this contributes to the still alarmingly high rate of introduction of invasive species, and the concomitant economic and environmental damage they cause.

The lack of objective data in some areas, and the unwillingness to use it in others, also contributes to this situation. Multi-and trans-disciplinary institutional and collaborative research in entomology and related disciplines (plant pathology, crop and soil science, nematology, weed science, etc.) is essential to increasing the basic understanding of the systems in which invasive species operate, and thus can help increase the success rate of programs. It is essential to have such international effort to understand the biology, ecology and control of invasive species.
The role that scientific societies such as the Entomological Society of America can play in this process is discussed.

FIELD TRAPPING LITTLE FIRE ANT, *WASMANNIA AUROPUNCTATA* (ROGER) (HYMENOPTERA: FORMICIDAE)

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Two detection methods for *Wasmannia auropunctata* (Roger), both employing the pheromone attractant 2,5-dimethyl-3-(2-methylbutyl)pyrazine (2-MeBu-diMePy), were compared with peanut butter based detection, in order to evaluate differences in species specificity and detection reliability. Trapping was conducted using a transect through a Macadamia nut orchard on the island of Hawaii. The transect consisted of a series of three-tree plots, with each plot containing a peanut butter coated stick (the most common current detection method used for *W. auropunctata* in Hawaii), a one-way trap treated with 2-MeBu-diMePy, and a piece of double-sided tape treated with 2-MeBu-diMePy. While there were no differences in the number of *W. auropunctata* counted with each detection method and no differences in detection reliability (detecting the known presence of *W. auropunctata* in a plot), the pheromone-incorporating methods showed greater species specificity, almost exclusively retaining *W. auropunctata*. These results demonstrate the potential of pheromone-detection methods to selectively capture target ant species even when other ants are present and abundant. Combined data from all three detection methods and a previous visual survey along the transect showed a marked difference in the frequency of cohabitation among ant species. Of the ten ant species collected, *W. auropunctata* was found as the lone ant species on a given tree at a significantly higher frequency than all other ant species except *P. fervens*. Ninety-four percent of the trees with *W. auropunctata* had only *W. auropunctata*, supporting previous observations that this species tends to displace other ant species. In addition, *Wasmannia auropunctata* microhabitat preferences were investigated using one-way traps containing 2-MeBu-diMePy, which were placed in three arboreal and three terrestrial locations. While the number of ants captured did not differ by trap placement, when grouped, captures were significantly higher in arboreal than terrestrial microhabitats.

THE DIFFERENTIAL INVASION POTENTIAL OF SIX MEDFLY BIOTYPES

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The Mediterranean fruit fly (medfly) has colonized a wide variety of temperate and tropical areas all over the world during the last few centuries. Medfly constitutes an ideal model species to study biological invasions due to its (a) almost cosmopolitan geographic distribution, (b) huge economic importance, and (c) well documented invasion history. Under a common garden experimental set up, we tested the hypothesis that medfly populations obtained from six global regions [Africa (Kenya), Pacific (Hawaii), Central America (Guatemala), South America (Brazil), Extra–Mediterranean (Portugal), and Mediterranean (Greece)] have diverged in (a) preadult survival and developmental times and (b) adult survival and reproductive schedules as a result of adaptation to ecologically diverse habitats. Therefore, we also tested the hypothesis that medfly populations from the above regions exhibit different population growth rates. Our results clearly show that medfly populations worldwide exhibit significant differences in preadult survival and developmental rates of immature stages. Females were classified as either short-lived [life expectancy at eclosion (e_0) 48-58 days; Kenya, Hawaii, and Guatemala] or long-lived (e_0 72-76 days; Greece, Portugal, and Brazil]. Lifetime fecundity rates were similar among populations. However, large differences were observed in their age-specific reproductive patterns. Short-lived populations mature at earlier ages and allocate more of their resources to reproduction early in life compared to long-lived ones. Our analysis, combining preadult survival and developmental rates, adult female survival and fecundity suggested significant differences among medfly populations in important population parameters such as the intrinsic rate of increase. Therefore, geographically isolated medfly populations may share different invasion potential, since population growth rates could influence basic population processes that operate mostly during the last two stages of an invasion event, such as establishment and spread. Our findings provide valuable information for designing population suppression measures and managing invasiveness of medfly populations worldwide.

ARTHROPOD PESTS OF TEA (*CAMELLIA SINENSIS* L.) IN HAWAI'I

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Green tea, *Camellia sinensis* L., is a new crop with excellent potential and economic outlook for Hawaii's farmers. The University of Hawaii's College of Tropical Agriculture and Human Resources (CTAHR) and farmers have successfully grown several varieties of tea at different

locations on Hawaii. A compilation of the major and minor arthropod pests of tea encountered to date in Hawaii are presented. Pests were collected from tea plants growing at the UH-CTAHR Mealani Research Station and from cooperating growers in other locations on the island of Hawaii. We have provided photographs and general information about these pests together with details on identification, crop damage, crop hosts, pest life cycle, and distribution. Accurate identification of the pest is essential for making sound pest management decisions. Early detection is often critical to eventual success in managing pests and reducing economic losses.

ARTHROPOD PESTS OF BLUEBERRIES IN HAWAI'I

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Blueberries are being introduced as a new crop for Hawaii agriculture. The University of Hawaii's College of Tropical Agriculture and Human Resources (CTAHR) have successfully grown several varieties of blueberries at different locations on Hawaii. A compilation of the major and minor arthropod pests of blueberries encountered to date in Hawaii are presented. Pests were collected from blueberry plants growing at the UH-CTAHR Mealani Research Station, Lalamilo Research Station and Volcano Research Station on the island of Hawaii. We have provided photographs and general information about these pests together with details on identification, crop damage, crop hosts, pest life cycle, and distribution. Accurate identification of the pest is essential for making sound pest management decisions. Early detection is often critical to eventual success in managing pests and reducing economic losses.

EFFECT OF LEAF VOLATILES OF PEPPER, POTATO, TOMATO AND A COMMERCIAL REPELLENT ON BEHAVIORAL RESPONSES OF THE POTATO PSYLLID, *Bactericera cockerelli* (Sulc)

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The potato psyllid, *Bactericera cockerelli* (Sulc), a polyphagous phloem feeder, can successfully reproduce on a wide variety of host plant species and is an important insect pest of potato and other plants around the world. In potatoes, direct feeding by the psyllid causes retarded growth, chlorosis, distorted leaves and small tuber production. It also transmits the bacterial pathogen "*Candidatus* Liberibacter psyllaurous" that causes a disease in potatoes known as Zebra Chip (ZC). The symptoms of ZC include internal brown discoloration in tubers and dark stripes when the affected tubers are processed to produce potato chips. ZC has caused millions of dollars in

losses to the potato industry in the USA. Major economic losses have also been reported in tomatoes and peppers. The most common method to control *B. cockerelli* is the application of foliar chemical insecticides. However, repeated applications are expensive, risk the development of resistance, and frequently reduce populations of beneficial insects, so it is necessary to explore alternative methods of control. The behavioral response of psyllid adults to plant odors and Specialized Pheromone and Lure Application Technology (SPLAT), a slow release formulation containing dimethyl disulfide, was studied in a glass Y-tube olfactometer. Initially, different quantities of pepper, potato and tomato leaves were tested until a significant and consistent response of potato psyllids to plant odors was observed. SPLAT, both with and without leaves present, showed a significant repellent effect on the psyllids, which persisted for more than 10 days in the laboratory. Plans for additional research including field trials will be discussed.

BIOLOGICAL CONTROL OF MEDICALLY IMPORTANT AEDES MOSQUITOES

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Results from ongoing laboratory and field experiments will be presented, including work toward a self-delivering microbial biopesticide for Aedes mosquito populations. Described experiments include (1) the development and laboratory testing of cytoplasmically incompatible strains, (2) proof of concept tests in small, laboratory cages, (3) mating competitiveness tests in semi-field cages and (4) the results of an initial feasibility trial with the open release of incompatible males.

DEVELOPING NEW TECHNOLOGIES FOR INSECT CONTROL IN SPECIALTY CROPS

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This talk will focus on the objective of IR-4 to support specialty crop pesticide uses in the United States via international harmonization. These activities are essential for making full use of scarce specialty crop residue data for exporting U.S. grown crops. IR-4 global activities will be discussed in detail.

INTEGRATING PRACTICES TO MANAGE SPOTTED WING DROSOPHILA, A NEW INVASIVE PEST IN SMALL AND STONE FRUITS

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Infestations of the spotted wing drosophila fly, *Drosophila suzukii* (Diptera: Drosophilidae; SWD), an invasive pest, was initially discovered in Oregon fruits in 2009. Questions are being

addressed regarding: SWD's seasonal phenology, population dynamics, reproduction potential, monitoring methods, overwintering capability, spring emergence, timing of egg-laying, fruit preference and susceptibility, chemical control and application timing, beneficial organisms and factors affecting mortality to better understand SWD in order to develop a best management plan. In addition, cultural and preventative practices including sanitation techniques, netting, mass trapping, and harvesting methods are being explored.

LIFE AND TIMES OF THE WĒKIU BUG

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There are innumerable examples in the insect world of species that are living marvels of evolutionary adaptation. But there are relatively few insects that receive attention from non-entomologists. Much to the detriment of the perception of insects and entomology, however, the public-at-large most often identifies insects as pests of home or farm, on TV as odd documentary subjects or forensic evidence on the crime-show du jour, or as the spotlight of an occasional environmental law controversy.

The wēkiu bug, *Nysius wekiuicola*, is one of those few aforementioned insects that have found its way into public notoriety due to its unique evolutionary characteristics and legal designation as a Candidate for Listing under the Endangered Species Act (ESA). It was described in the early 1980s from a putatively barren and lifeless alpine desert environment. The wēkiu bug is only found in the summit region of Mauna Kea on the island of Hawaii above 11,000ft, and it depends wholly on wind blown, gravity deposited insect prey from much lower elevations. The wēkiu bug's ancestral lineage in Hawaii is comprised of herbivorous seed bugs in the cosmopolitan genus *Nysius*. Hawaii holds a full quarter of the world's *Nysius* species, and the morphological diversity seen on these islands is greater than the rest of the world's species. The wēkiu bug appears to be the strangest of these species, with elongated legs, micropterous flightlessness, carnivorous feeding, and the ability to survive extremes in temperature, blanketing snowfall, drastic fluxes in water availability and solar radiation.

Without formal investigation, the wēkiu bug gained much attention when it was described as rare in the early 1990's, and its odd life history was aggrandized by the media and books. Prior to the ESA petition, the only formal scientific manuscripts published on the wēkiu bug were its species description by Ashlock and Gagné in 1983 and an investigation in 1991 into supercooling abilities of three arthropod species found at near the summit of Mauna Kea. There have been repeated and more formal efforts to study the wēkiu bug over the past 10 years, mostly spurred by legal requirements for the University of Hawaii and the State to better manage the land in the Mauna Kea Science Reserve (MKSR), comprising the only known wēkiu bug habitat. The MKSR is among the best places in the world for ground-based astronomy, and because of this, it has seen a proliferation of telescope facilities, including the nearly finalized location of the proposed Thirty Meter Telescope. In the past, these facilities have been built on prime wēkiu bug habitat, and how that impact has affected the continued survival of the species is still debated.

There was a need to determine effective management protocols for the habitat and populations of these elusive wēkiu bugs, but there was scant information scientifically validated on which to base any species management decisions. We investigated unknown aspects of the wēkiu bug's life history using standard life table and degree day approaches, which are commonly used in agricultural entomology. We gained important insights into how the wēkiu bug can survive, grow and reproduce in its extremely harsh natural environment, and helped explain field trapping observations of density and distribution. Also, using population-level genetic analyses of mtDNA haplotype diversity, we described the potential impacts of habitat destruction in distinct populations throughout their range. Finally, we investigated the evolution of the wēkiu bug within its phylogenetic *Nysius* lineage using mtDNA and nDNA (COI, COII, EF1-alpha) to show how this unique species could have evolved in these isolated Hawaiian Islands. Overall, we have provided an initial knowledge base that resource managers can use to guide the protection of the species without the typical dearth of applicable and actionable details of life history. Management of this and other rare insect species can and should be based on applied science, and it is surprising that more of the scientific tools developed for agricultural entomology have not been directly used for conservation management of threatened insects.

STRENGTHS AND WEAKNESSES OF SPECIES-CENTRIC CONSERVATION PRACTICES FOR INSECTS: A HAWAIIAN CASE STUDY USING THE WEKIU BUG

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Preserving rare insect species and conserving arthropod biodiversity has largely been viewed as a probable byproduct of conservation practices, rather than a targeted goal, even though the essential role of insects in all ecosystems is well known. In Hawaii, where plant and animal endemism is among the highest in the world, conservation biology has continued to focus very little on the status of or threats to insects, with the exception of a comparative few high profile species that have received protection under the Endangered Species Act (ESA). However, is insect conservation in Hawaii well served by this species driven model? The wekiu bug, *Nysius wekiuicola*, found only in the summit region of Mauna Kea on the island of Hawaii, depends wholly on wind blown, gravity deposited insect prey from much lower elevations. Due to its limited range, specific habitat requirements, isolated populations, and habitat destruction, the wekiu bug is currently a candidate for listing under the ESA. This insect has halted telescope construction in its elevation range for years, become acknowledged in the public eye as a creature uniquely Hawaiian deserving attention, and has been the focus of at least three large scientific research and monitoring projects. Our five year project culminated in the recommendation of protecting a specific habitat comprising 25% of the area in its elevation range. However, if the ultimate goal of conservation is preserving native biodiversity, what are the benefits and opportunity costs of this effort, compared to the alternative: a broader conservation strategy not focused on an individual species?

SPATIAL AND TEMPORAL DYNAMICS OF PREDATOR RESPONSES TO VARIABLE PREY DENSITY: LADY BEETLES AND APHIDS

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The population response of predators to locally varying prey density is often a key driving force in predator-prey dynamics. Theorists have developed models of such responses as based on variable rates of predator immigration and emigration to and from local prey patches. Depending on their assumptions, these models lead to different predictions as to how predators are distributed among patches of their prey. Three basic outcomes are those of the ideal free distribution (in which the ratio of predators to prey is constant over space) and under or overmatching (with the ratio of predators to prey either decreasing or increasing with an increase in local prey density). I will present results from a field experiment in spring alfalfa in which the local density of pea aphids was manipulated, and the numbers of adult lady beetles (Coccinellidae) associated with local aphid populations were determined over the two-week period following experimental manipulation. I will assess how the basic pattern of predator spatial distribution (adherence to the ideal free distribution, under or overmatching) among prey patches changes over time. I will interpret the results in light of model assumptions to assess how adult lady beetles may track their aphid prey over relatively small scales of space and time (scales of tens of meters and of days).

A NOVEL ATTRACT-AND-KILL STRATEGY FOR SUPPRESSION OF HOP LOOPER IN HOPS

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Hop loopers (*Hypena humuli* (Lepidoptera: Noctuidae)) can cause economic damage when they feed on the leaves and cones in hop yards during mid to late summer. Population outbreaks of hop looper have increased in recent years as producers have shifted toward using softer insecticides such as *Bacillus thuringiensis*, spinosad, and spinetoram, which are very effective against early instar larvae but not as efficacious against larger larvae. Control of later instar larvae often requires broad-spectrum insecticides such as bifenthrin. Unfortunately, pyrethroids such as bifenthrin, applied in a broadcast treatment, can decimate beneficial arthropods. In addition, their use will often contribute to outbreaks of spider mites. During the seasons of 2003-2005, we demonstrated that we could significantly reduce local populations of cutworm moths in wine and juice grape vineyards at a deployment rate of 50 attract-and-kill bait stations per acre. Each bait station contained feeding attractant consisting of 1:1 isoamyl alcohol:glacial acetic acid; the bait station was smeared with a pyrethroid/PTFE grease mixture. The feeding attractant, originally designed by Dr. Peter Landolt, USDA-ARS, for the Lacanobia fruitworm, also attracts many other noctuids. Bait station work in vineyards was discontinued in 2005 due to widespread adoption of an alternative application methodology, which involves targeting a low dose of pyrethroid to the base of the vine, in a band at the trunk/soil/trellis interface, to prevent cutworms from climbing up the trunk to feed on the developing buds. This popular, low-input, barrier spray

technique proved highly cost-effective in grapes but is not applicable for control of moth pests in hops because of life history differences: cutworm pests of grapes overwinter in the soil or in the duff around the vine plants, while hop loopers and other moth larvae emerge from eggs laid on hop leaves. However, the low-input, attract-and-kill technology utilized in grapes was expected to work similarly in hops to control hop looper because hops and grapes are both wind-pollinated and neither possess extrafloral nectaries that might compete with feeding attractant in bait stations.

Thus, in early June 2010, bait stations made of PVC slip tee fittings were screwed to hop poles in three hop yards in Yakima County, WA. One grower discontinued farming his hop yard, leaving only two hop yards in the experimental design. The PVC tees were smeared on the inside and outside with β-cyfluthrin (2.5% a.i.) in food-grade lubricant. Plastic vials containing feeding attractant were screwed into the tee bottoms. A randomized complete block design of five-acre plots with three treatments (0, 10, and 60 bait stations/acre) replicated four times was set up for each hop yard. Moth populations were sampled weekly beginning in mid May (pre-deployment) with universal bucket traps baited with feeding attractant. From June to August, insects on hop plants were sampled biweekly by shaking three bines into a large funnel and collecting insects in a container below the funnel. Hop looper moth numbers were quite low early in the season but peaked in the Moxee hop yard control plots in July, when a total of 2,110 were trapped. In both hop yards, significantly fewer moths were found in the 10 and 60 bait stations/acre plots than in the control plots in July, which was approximately one month after deployment of bait stations. Throughout the season, numbers of hop looper and other lepidopteran larvae collected were quite low, thus, no effects due to bait stations were observed. At both locations, the most abundant pest moth in the feeding attractant bucket traps was hop looper, followed by spotted cutworm, Bertha armyworm, and common gray moth. The most abundant larval pest found was hop looper followed by common gray in the Moxee hop yard. In the Toppenish hop yard, common gray larvae were found more often than hop looper larvae. Our data suggest that while the attract-and-kill technology can significantly reduce hop looper moth populations, it does not similarly affect the abundance of other pest moths in hops.

LETHAL EFFECTS OF NEW GENERATION PESTICIDES ON THE CONVERGENT LADYBIRD BEETLE (*HIPPODAMIA CONVERGENS*)

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As a replacement for neurotoxic broad spectrum pesticides, a new class of reduced risk pesticides has been developed. Though such pesticides may pose a reduced risk to human health, they have not been evaluated for effects on natural enemies. Several pesticides were evaluated for lethal effects on the convergent ladybird beetle (*Hippodamia convergens*), which is an important natural enemy in agricultural ecosystems. The effects of residual exposure on adult *H. convergens* were recorded for five different types of pesticides commonly used in orchards within the Western United States: diamides (Altacor, Cyazypyr), fungal metabolites (Delegate), insect growth regulators (Rimon), pyrethroids (Warrior II), and fungicides (Kumulus, Kocide-Manzate). Individual insects were placed in glass vials coated with a given pesticide that were applied at the field rate concentration or 10% of the field rate. After a period of 48 hrs, mortality

rates were recorded. Mortality rates for Altacor, Cyazypyr, Rimon, and Kocide-Manzate were less than 10% for each pesticide, regardless of concentration. Residual exposure to these pesticides does not appear to cause significant mortality in *H. convergens*. However, further research is needed to determine lethality from oral exposure and sublethality and its effects on population dynamics.

DIPTERAN PARASITOIDS ENFORCE PERIODIC POPULATION DYNAMICS OF GRASSHOPPERS IN SUBARCTIC REGIONS.

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Several species of grasshopper in Alaska exhibit periodic population dynamics with abundant and scarce cohorts in alternate years. This is a common phenomenon in cold climates where many insects require two years to complete their life cycle. Different mechanisms have been proposed to account for the dramatic differences in abundance of populations in alternating years. One likely mechanism may be parasitoids with a one-year life cycle. It has been suggested that scarce hosts in one year limit parasitoid populations which are then saturated by abundant hosts in the following year. Grasshopper populations were sampled to determine rates of parasitism by dipteran parasitoids for four years. At least three species of Diptera (Sarcophagidae and Tachinidae) were found to attack grasshoppers. Rates of parasitism were much higher during years of scarce hosts than in alternate years of abundant hosts, which is consistent with the hypothesis that periodic dynamics arise from the two-year host life cycle and the one-year life-cycle of the parasitoids. With a warming climate, a one-year life-cycle may become possible for a portion of the population in some years. A simple model of parasitoid-host dynamics is adapted to explore how periodic population dynamics may break down as a one-year life-cycle becomes more common in subarctic regions.

FEEDING PREFERENCE AND IMPACT ON AN INVASIVE WEED (*CREPIS TECTORUM L.*) BY A NATIVE, GENERALIST GRASSHOPPER, *MELANOPLUS BOREALIS* (ORTHOPTERA: ACRIDIDAE)

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Crepis tectorum L., narrow leaf hawksbeard, was first collected in Alaska in 1974 and by 2004 was a common weed in agricultural fields. Introduction and establishment of a new plant species in a region represents a potential new resource for herbivores, as well as a new competitor for plant species already present. Objectives of this study were to determine the preference for *C. tectorum*, relative to other common plant species, by *Melanoplus borealis*, a generalist herbivore grasshopper common in Alaska, and to determine the potential impact of grasshoppers on this weed. In choice tests, *M. borealis* preferred *C. tectorum* over two native forbs, and a grass species, but dandelion, *Taraxacum officinale*, was preferred over *C. tectorum*. In field cages, in each of three years, grasshoppers reduced biomass of mature plants, flowers, and seedlings of *C. tectorum*, but not other forbs. We conclude that this weed is a readily accepted new food

resource for generalist-feeding grasshoppers, and although grasshoppers could potentially limit seed production of *C. tectorum*, generally grasshopper densities are not high enough to have significant impact on the weed populations.

IRRADIATION FOR QUARANTINE CONTROL OF LIGHT BROWN APPLE MOTH

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Light brown apple moth (LBAM), *Epiphyas postvittana* (Walker) (Lepidoptera: Tortricidae), is an invasive pest that has become established in California. LBAM is currently a regulated pest in seven foreign countries, including Canada, Chile, Korea, Mexico, Peru, Thailand, and South Africa, and these countries require phytosanitary certificates stating that products have been inspected and found free of any stage of LBAM. Irradiation is a postharvest quarantine treatment option for exported commodities to prevent movement of viable light brown apple moth. The effects of irradiation on egg, larval, and pupal development, and adult reproduction in LBAM were examined. Eggs, neonates, early instars, late instars, early pupae and late pupae were irradiated at target doses of 60, 90, 120, or 150 Gy or left untreated as controls in replicated factorial experiments and survival to the adult stage was recorded. Tolerance to radiation generally increased with increasing age and developmental stage. For most commodities, the fifth instar is the most radiotolerant life stage likely to be associated with the commodity, and a minimum radiation dose of 150 Gy will prevent adult emergence from this stage. For commodities such as table grapes that may contain pupae, a radiation dose of 200 Gy may sterilize emerging adults and this would be an effective all-crops irradiation treatment.

INTEGRATING PRACTICES TO MANAGE SPOTTED WING DROSOPHILA, A NEW INVASIVE PEST IN SMALL AND STONE FRUITS

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Infestations of the spotted wing drosophila fly, *Drosophila suzukii* (Diptera: Drosophilidae; SWD), an invasive pest, was initially discovered in Oregon fruits in 2009. Questions are being addressed regarding: SWD's seasonal phenology, population dynamics, reproduction potential, monitoring methods, overwintering capability, spring emergence, timing of egg-laying, fruit preference and susceptibility, chemical control and application timing, beneficial organisms and factors affecting mortality to better understand SWD in order to develop a best management plan. In addition, cultural and preventative practices including sanitation techniques, netting, mass trapping, and harvesting methods are being explored.

INTEGRATED MANAGEMENT OF ALIEN PREDATORS IN HAWAII VOLCANOES NATIONAL PARK

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Efficacy studies for chemical control of wasps and rats have been carried out at Hawaii Volcanoes National Park over the past decade. In both cases, successful local suppression of these predators has been demonstrated and a special local needs registration for chemical control of rats using broadcast baits was obtained in 2007. The contrasting population biology of park rodents and yellowjacket wasps coupled with the mechanics of bait application illustrate how joint management programs for these species can be integrated. Examples of successful predator control in park "kipukas" are discussed in the context of long-term forest restoration programs undertaken by the National Park Service.

NOVEL APPROACHES FOR EDUCATING PEST MANAGEMENT PROFESSIONALS ABOUT BED BUG AND STRUCTURAL PEST IPM

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Washington State University Puyallup constructed a Structural Pest IPM Facility where pest management professionals are trained in a unique educational environment with hands-on IPM training for bed bugs and structural pests. The IPM Facility was built with several types of siding and roofing, a crawl space, and an unplumbed bathroom to simulate 'real world' pest-conducive conditions. Modular panels of damaged wood with insect frass or other remains have been incorporated into the facility to create a teaching laboratory. The WSU IPM Facility was built as a collaborative project with involvement from the pest management industry, the Washington State Department of Agriculture, the Western IPM Center, and WSU Extension. Structural pest IPM curriculum for hands-on courses was developed as a regional effort and hundreds of 'students' have been trained in the identification of structural pests, conditions conducive to pest infestations and IPM. Working with industry partners, the WSU Urban IPM Program has expanded course offerings to include hands-on bed bug IPM training. Pest management professionals are trained in the biology, inspection techniques and IPM strategies for managing bed bugs. Our goal is to reduce the number of inaccurate wood-destroying organism inspections, and the potential health risks from unnecessary or improper pesticide applications for bed bugs and other pests in structures.

BIOLOGICAL CONTROL AND THRIPS COMPETITION

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In its native southwestern North America with Mediterranean and semi-arid climates, Frankliniella occidentalis employs an opportunistic life history strategy, with population characteristics that include polyphagy, rapid development, high reproductive potential, vagility, and a competitive breeding structure. The species, now considered cosmopolitan, is thought to have successfully invaded regions with many different climates. In Chile, Turkey, Argentina, and greenhouses, F. occidentalis has displaced other thrips species. In the eastern USA, F. occidentalis is an inferior competitor to the native thrips on both cultivated and uncultivated plant hosts, and this competitive asymmetry, along with a reduced ability to avoid predation compared to the native flower thrips, has resulted in its exclusion (but not repulsion) in the agroecosystem. There are only rare opportunities in space and time for natural population buildup on plant hosts in the absence of predation and competition. However, the species is capable of exploitation of insecticide-treated crop fields where they rapidly increase to damaging pests in the absence of predation and competition. Apparently, F. occidentalis similarly encounters serious biotic resistance, even near complete repulsion, in many geographic regions with different climates. Observations show that populations occur in high numbers in insecticide-treated crop fields; only small populations in the form of stray individuals are encountered on the other available plant hosts. Examples of successfully using interspecific competition and biological control to manage thrips will be discussed.

EFFECT OF METHYL SALICYLATE LURES ON *TYPHLODROMUS PYRI* (ACARI: PHYTOSEIIDAE) AND OTHER NATURAL ENEMIES IN VINEYARDS

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The predatory mite *Typhlodromus pyri* is considered a key biological control agent of the grapevine rust mite, *Calepitrimerus vitis*. Methyl salicylate (MeSA), an herbivore induced plant volatile, can potentially elicit top-down control of pests through attraction of beneficial arthropods. This study evaluates the effect of synthetic MeSA lures (PredaLure) in two vineyards on arthropod populations during 2009-2010 seasons. MeSA lures were deployed at a low (4/plot) and high (8/plot) rate in ~ 152 m^2 plots while control plots contained no lure. Each treatment contained three replicates per site. Leaf samples were collected to assess *T. pyri*, Eriophyid, Tetranychid and Thripidae densities. Yellow sticky traps were used to monitor other key arthropods. Overall *T. pyri* population densities at Salem were higher in control plots compared to MeSA plots. Comparisons of treatment by date revealed significantly ($P < 0.05$) lower numbers of *T. pyri* in treated plots in the middle (2009) and early (2010) growing season. In contrast, mean seasonal abundance of *T. pyri* was higher in MeSA plots at Dayton during both seasons. Significantly higher counts of *T. pyri* were shown in high rate MeSA plots in 2010 early in the season. Coccinellidae mean seasonal trap counts were significantly higher in MeSA

plots in both years at the Dayton vineyard. MeSA plots did not show significantly higher or lower *C. vitis* populations. In 2009 at Salem, pest thrips densities were significantly lower in low rate MeSA plots late in the season although no trend of decreased seasonal abundance was evident.

RNA-SEQ ANALYAIS OF THE ORIENTAL FRUIT FLY (*BACTROCERA DORSALIS)*

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The oriental fruit fly is a pest Tephritid species of particular economic importance. In Hawaii, the oriental fruit fly and other Tephritid species limit development of a diversified fruit and vegetable industry, require export fruits to undergo expensive quarantine treatments, and provide a reservoir for pest introduction into the mainland United States. Potential introduction to the U.S. mainland could cause large economic impact. In California where the total value of the fruit and vegetable industry has been estimated to be more than $14 billion annually, the California Department of Food and Agriculture has estimated that an established infestation of fruit flies would cost up to $1.4 billion during the first year of establishment. Despite the economic importance of tephritids, very little molecular information is available for this family of insects. To address this, as part of the oriental fruit fly genome sequencing project RNA-seq analysis was performed on different life stages of *B.* dorsalis. Deep transcriptome sequencing was performed on the Illumina GA IIx platform. Six RNA libraries were prepared from whole *B. dorsalis* from different developmental stages (egg, larvae, pupae, adult) and sequenced (2 x 100 bp PE sequencing), with the expectation of obtaining the widest range of gene transcripts from a combination of these samples. *De novo* assembly of these libraries was performed, sequences annotated and differential expression measured between life stages of this fly. This gene set will be used to direct annotation of the oriental fruit fly genome, and lays the foundation for functional genomics projects within this fly species.

MONITORING HOUSE FLY ACTIVITY ON COMMERCIAL DAIRY OPERATIONS: THE START OF A DAIRY IPM PROGRAM

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Relative house fly activity at three large dairies in central California was monitored during the peak fly activity period from June-August 2005 using spot cards, fly tapes, bait traps, and Alsynite traps. Counts for all monitoring methods were significantly related at two of three dairies; with spot card counts significantly related to fly tape counts recorded the same week, and both spot card counts and fly tape counts significantly related to bait trap counts 1-2 weeks later. Mean fly counts differed significantly between dairies, but a significant interaction between dairies sampled and monitoring methods used demonstrates that between-dairy comparisons are

unwise. Estimate precision was determined by the coefficient of variability (CV) (or standard error / mean). Using a coefficient of variability (CV) = 0.15 as a desired level of estimate precision and assuming an IPM action threshold near the peak house fly activity measured by each monitoring method, house fly monitoring at a large dairy would require 12 spot cards placed in mid-afternoon shaded fly resting sites near cattle or 7 bait traps placed in open areas near cattle. Software (FlySpotter©) using computer vision technology was developed to count fly spots on a scanned image of a spot card in order to dramatically reduce time invested in monitoring house flies. Counts provided by the FlySpotter© software were highly correlated to visual counts. The use of spot cards for monitoring house flies is recommended for dairy IPM programs.

REDUCTION OF PESTICIDE INPUTS FOR CONTROL OF EUROPEAN CORN BORER IN BELL PEPPER USING CORAGEN® VIA DRIP IRRIGATION

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The European corn borer (*Ostrinia nubililalis* Hubner) (ECB) (Lepidoptera: Pyralidae) is the most important economic pest of bell peppers throughout the mid-Atlantic region of the U.S. Borers crawl under the fruit calyx and bore into, and feed on, the placenta, immature seeds and pericarp, rendering the fruit unmarketable. Infested fruit often rot and drop from the plant before harvest. To protect the fruit, growers begin weekly sprays when moths are active and fruit pepper fruit are >1.3 cm diameter (late July – early August) and continue sprays until harvest is completed (late October), for a total of 8-12 foliar sprays. Nearly all pepper production in NJ utilizes black plastic mulch with drip irrigation. A new-chemistry insecticide, chlorantraniliprole, is highly soil systemic, very soluble, and effective against Lepidopteran larvae at low rates, thus is an ideal candidate for chemigation. A 3-yr study applying chlorantraniliprole through a drip irrigation system in bell peppers demonstrated that, on every harvest date examined, 2-4 applications of chlorantraniliprole were as effective, or more effective, in reducing percentage borer-infested peppers than a standard grower pesticide program of multiple applications of acephate and indoxycarb each year. This application method reduces grower pesticide inputs, tractor fuel, time of application, and costs of spray equipment, and could be useful in vegetable row crops such as tomato, eggplant, cabbage, and others.

IMPROVED MANAGEMENT OF COTTON APHIDS IN COTTON AND CITRUS: IMPORTANCE OF OVERWINTERING POPULATIONS IN POMEGRANATES

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Cotton aphid, *Aphis gossypii* Glover, is a highly damaging insect pest to several crops in CA, e.g., citrus, cucurbits, cotton, celery, eggplants, nursery plants, etc. This pest, with >300 reported hosts, hinders the agricultural economy by reducing crop yields via removal of crop photosynthates, contaminates commodities with excreted honeydew and insect parts, transmits serious virus diseases, and contributes to increased crop protection costs. In recent years, aphid populations in cotton, which threaten the quality of the harvested lint, and citrus tristeza virus (CTV), an aphid-transmitted virus of citrus, have been severe problems. The incidence of CTV has increased significantly in recent years in the eastern San Joaquin Valley citrus production area. Pomegranates are the only identified overwintering/primary host for cotton aphid in CA and the CTV increase has occurred concomitant with an increase in pomegranate acreage in this region. Through this project we have been studying several key characteristics of the overwintering biology of this species. Investigations and refinement of management plans for cotton aphid on the overwintering host, pomegranates, may represent a 'weak point' in the life cycle and may offer a unique opportunity to favorably impact management of this key pest. Biorational insecticides, cultural, and biological approaches are being investigated.

IMPACT OF NATURAL ENEMIES ON WOOLLY APPLE APHID SUPPRESSION

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Woolly apple aphid (WAA) *Eriosoma lanigerum* has become a pest of increasing importance in Washington State for the past few years. The increase in aphid outbreaks appears to be associated with the disruption of biological control ignited by some orchard pesticides. Various natural enemies have been documented to prey on/parasitize WAA. However; little is known about their actual impact on WAA suppression out in the field. In this study, exclusion cage experiments were conducted to investigate the effect of natural enemies on WAA suppression. The three cage treatments used were: 1) WAA alone (control), 2) WAA + parasitoid (cage allows only parasitoid) and 3) WAA + parasitoid + predators (cages allows everything). Both experimental runs showed that the parasitoid alone can reduce WAA numbers, but can not suppress it. In contrast, predators together with parasitoid showed to be able to suppress WAA.

ESTABLISHMENT OF AN ECONOMICALLY VIABLE CELERY IPM PROGRAM

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Economical decisions often dictate pesticide application selections when it comes to establishing an IPM program. If commercial operations can realize a profit using a particular IPM program then they are more willing to accept a change from conventional protocol. Our goal was to make a comparison between a conventional application program and a low input IPM program in order to identify the best economically viable approach for the commercial production of celery that

complies with the Food Quality Protection Act, maximizes worker safety, and reduces resistance development. New biorational insecticides were tested to determine if they were effective in controlling celery pests. The better performing compounds were utilized in a comprehensive IPM program. Commercial scale replicated field trials were conducted in a randomized complete block design at the South Coast Research and Extension Center. Upon completion of the trials, the celery was harvested and analyzed for insect damage. These data were then subjected to a simple, partial budget economic analysis, to determine the economic potential of the low input program. The results and the continuing development of an IPM program are discussed.

HAWAII TERMITES 101

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Over the past two decades, the number of termite species established in Hawaii has doubled from four to eight. These include two subterranean (or ground) termites), five drywood termites, and one dampwood (or rotten-wood) termite. The recent invaders have limited distributions in Hawaii, but three of these termites are major pests in other parts of the world; and in at least two cases, their distributions in Hawaii have expanded since their original discovery. The eight termite species now known to occur in the state are *Coptotermes formosanus* (Formosan subterranean termite), *Coptotermes gestroi* (Asian subterranean termite, previously known as *C. vastator*), *Cryptotermes brevis* (West Indian drywood termite), *Cryptotermes cynocephalus* (Philippine house termite), *Incisitermes immigrans* (lowland tree termite), *Incisitermes minor* (Western drywood termite), *Neotermes connexus* (forest tree termite), and *Zootermopsis angusticollis* (Pacific dampwood termite). Of these eight termite species, *Coptotermes formosanus*, *C. brevis*, *I. immigrans*, and *N. connexus* have long been established in the islands, while the other four species are recent, but persistent, arrivals. This presentation reviews the current distribution of termites in Hawaii; how to distinguish among them; differences in their behavior, physiology and management indicated by recent research; and their relative pest potential.

ADDITIONAL STRATEGIES FOR LIMITING INSECTICIDE RUNOFF FROM HOMES TREATED FOR ARGENTINE ANT INFESTATIONS

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We have previously shown that when using fipronil treatments around homes infested with Argentine ants, treatments restricted to house foundations can result in acceptable ant control while reducing the amount of fipronil runoff due to summer irrigation. However, a 40-gal driveway and garage door flush showed that significant amounts of fipronil remained after 8 weeks and could potentially runoff with precipitation. We report here on additional application techniques to see whether runoff could be reduced further. All treatments were limited to 1-gal.

In addition to a standard fipronil spray, around house foundations we applied fipronil as wet and dry foams, as crack and crevice treatments with a pin stream applicator, and finally as a standard spray but leaving the garage door/driveway interface untreated. For each of these treatments we measured efficacy against the ants and the amount of insecticide runoff. In general, all the 1-gal fipronil treatments were equally effective in reducing ant numbers. Significantly, not treating the garage door area lowered the runoff from the 40-gal drive flush. A tentative conclusion is that ant control is still effective if the garage door/driveway interface is not treated while simultaneously reducing the future potential for runoff from heavy precipitation.

FITNESS OF DIFFERENT CLONAL LINEAGES OF PENTALONIA APHIDS REARED ON BANANA LEAVES

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Aphids are known to form host plant races that may affect their potential to perform across different hosts and transmit plant viruses. Pentalonia nigronervosa Coquerel, the banana aphid, is the sole vector of *Banana bunchy top virus* (BBTV) the most destructive viral pathogen affecting banana worldwide. In a recent study, Pentalonia aphids from plants in the family Musaceae and Araceae/Zingiberaceae were categorized, on the basis of morphological and molecular characters, into two distinct species, *Pentalonia nigronervosa* and *Pentalonia caladii*. This study was undertaken in Hawaii to determine if distinct clonal lineages of Pentalonia are capable of developing and reproducing on banana. Twelve clonal lineages were established from individual apterous aphids living on Heliconia, Banana, Taro and Ginger plants. These clonal lineages were kept on their original host plants until the commencement of the experiment at which time members of all colonies were reared on small banana leaf disks in an environmental growth chamber. Survival and fitness on banana was assessed by constructing single decrement life tables under laboratory conditions. Through life table analysis we determined: the intrinsic rate of increase, the net reproductive rate, doubling time, and generation time. We also determined the mean development time, adult longevity, fecundity, life expectancy and survival rates. Our findings indicated that with various degrees all clonal lineages of Pentalonia tested were capable of developing and reproducing on banana under laboratory conditions. Transmission efficiency of BBTV is also being evaluated for all of these lineages, with that data forthcoming.

BIOGEOGRAPHY AND BIODIVERSITY OF ARTHROPODS FROM OHIA LEHUA (*METROSIDEROS POLYMORPHA*), FOUNDATION OF HAWAIIAN FORESTS

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Metrosideros polymorpha (ohia lehua) is the dominant canopy tree in mesic to wet forests on all main islands, and is also important in diverse habitats on recent basaltic lava flows to high elevation bogs. Thus, a basic understanding of diversity patterns of *Metrosideros* arthropod communities can yield information applicable to many forests throughout the islands. I will

present biodiversity patterns from different islands and from a series of experimental manipulations, past and present, in volcanic habitat mosaics on the island of Hawaii. This integrated community-level approach along a time series from 150 year to 5 million years old provides insight into the formation, maintenance, and ultimately senescence of Hawaiian forest biodiversity.

RESPONSE OF SUMMERFORM PEAR PSYLLA (HEMIPTERA: PSYLLIDAE) TO MALE- AND FEMALE-PRODUCED ODORS

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We examined the role of chemical signals in sex attraction of pear psylla, *Cacopsylla pyricola* (Förster), assessing response of summerform male and female psyllids to both male- and female-produced volatile chemicals. Male psyllids were attracted to odors from live females and pentane extracts of females. Extracts from females were as attractive to males as live females, suggesting that the female-produced volatile chemicals responsible for male attraction might be isolated by extracting females with pentane. Females were not attracted to odorants from live females and tended to avoid odorants from extracts of females. Furthermore, summerform males and females were not attracted or repelled by male-produced odorants from live males or extracts of males. Results of olfactometer assays using male summerform *C. pyricola* are consistent with results from earlier studies with the winterform morphotype of this species.

CONTRASTING PATTERNS OF POPULATION STRUCTURE IN EIGHT SPECIES OF CONGENERIC HAWAIIAN LEAFROLLER MOTHS (*OMIODES*: CRAMBIDAE)

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Although insects comprise the bulk of Hawaiian biodiversity, little is understood about the population structure of Hawaiian insect species as it relates to geography and ecology. Using mitochondrial DNA sequences, we explored population structure in eight different species of Hawaiian leafroller moths in the genus *Omiodes* (Crambidae), including both common and rare species. Analysis of Molecular Variance (AMOVA) and Isolation by Distance (IBD) analyses revealed a range of patterns across species: some species had high genetic structure with relation to islands, while others were panmictic across their range. Species with high host specificity, especially those that relied only on native host plants, showed higher degrees of geographic isolation, while generalist species capable of using non-native plants tended to have high gene flow among islands. However, some species that were panmictic and showed high genetic diversity throughout their current range have apparently been extirpated from some islands where they formerly occurred, suggesting that they are not immune to extinction.

THE HIGH COST OF INVASIVE PESTS: AN ECOLOGICAL, REGULATORY, AND IPM PERSPECTIVE

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There is a tremendous amount of species diversity and unique ecological habitats in Tennessee. The introduction of invasive pests and disease has been especially disruptive to our forest habitats and has been degrading them rapidly. One problem with invasive pests and diseases is that once they become established, they often continue to be a significant and costly problem. Japanese beetles and imported fire ants are two pests that have required continuous regulatory efforts while also being costly to control by producers and the general public. There has been a large increase in insecticide use by our nursery industry where these pests have moved into our key nursery production counties. The growing reliance on extensive chemical control for these pests is contrary to our IPM program goals of reducing pesticide use and worker exposure. The gypsy moth is an example of an insect that has required extensive and costly regulatory action over many years to detect and eradicate the ever increasing introductions. Other pests such as hemlock woolly adelgid are spreading quickly throughout hemlock habitats in the state. Chemical and biological control programs are inadequate to stem the tremendous losses that are occurring. The recent increase in disruptive pests and diseases such as thousand cankers disease and emerald ash borer has magnified the problem. The availability of adequate resources for research, management, and education from state, federal and the private sector is becoming a major concern.

SHORT AND LONG-TERM CONTROL OF THE WESTERN YELLOWJACKET WASP (*VESPULA PENSYLVANICA*) IN HAWAII BY TOXIC BAITING

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Invasive species are widely recognized as one of the leading threats to global biodiversity and are a primary cause of decline of Hawaii's endemic species. The Western yellowjacket wasp, *Vespula pensylvanica*, was first reported in Hawaii Volcanoes National Park (HAVO) in 1978 following a rapid range expansion throughout the Hawaiian Islands in the late 1970s. *Vespula* are generalists arthropod predators and consume copious amounts of nectar to further subsidize their energy demands. The expansion and competitive advantages of invasive *V. pensylvanica* in Hawaii may lead to the extinction of native invertebrates and endemic birds, which may have indirect effects on the reproduction of native plants. The purpose of our study was to: (i) Determine the immediate and long-term efficacy of three years of annual 0.1% fipronil toxicant baiting on yellowjacket populations in Hawaii and (ii) Measure the effects of the addition of a long range synthetic attractant, Heptyl butyrate, on the attraction to bait used for yellowjacket control. All the wasp colonies (n=27) within five 9-hectare fipronil treatment sites were

destroyed and all the *Vespula* activity indices differed significantly over time between the two treatments (fipronil and non-toxic) within and across treatment years. The 0.1% fipronil toxicant bait reduced the abundance of *V. pensylvanica* by 91-98% within the treatment year and the carryover impact of the previous years' treatment maintained a population reduction of 55-67% in the fipronil treated sites when compared to non-toxic sites. Wasps took significantly more bait from dispensers with heptyl butyrate wicks. Thus, the impact of heptyl butyrate on *V. pensylvanica* forager behavior has the potential to increase the efficacy and decrease the duration of toxicant baiting. The results of this study strongly indicate that 0.1% fipronil toxic chicken meat with the additional of a heptyl butyrate wick is effective at the immediate and long-lasting control of yellowjacket populations in Hawaii.

IS THAT YOUR FINAL ANSWER? TRAMP ANTS IN THE PACIFIC NORTHWEST

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Pest management professionals and extension personnel have assisted in the identification of pest ants, specifically tramp ants discovered in the Pacific Northwest. Ant identification workshops devoted to native ant species that are wood destroying and nuisance pests, plus an introduction to tramp ants have played a major role in the identification of ants that are not native to the area. Distribution of tramp ants occurring in tropical and subtropical areas that have been identified or are now residing in the Pacific Northwest and southern Canada include the following: ghost ants (*Tapinoma melanocephalum*) in Portland and Edmonton; white-footed ants (*Technomyrmex difficilis*) in Seattle; European red fire ants in Seattle, Vancouver, and Victoria; *Wasmannia auropunctata* in Vancouver; Ponerine ants (*Hypoponera punctatissima*) throughout Washington; Argentine ants (*Linepithema humile*) in Seattle; Rover ants (*Brachymyrmex depilis*) in Portland and Seattle. Although some species have been present for a number of years, these populations have been generally confined to specific areas.

PREFERENCE OF NATIVE OR INVASIVE PLANTS BY NATIVE *BOMBUS* INFLUENCED BY NUTRITION AND AVAILABILITY

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Native bees have been observed both visiting a significant portion of some invasive plant species as well as completely ignoring others. However, the mechanism explaining this is poorly understood and little is known about bee preference and choice. Using *Bombus vosnesenskii* as a model species we collected and identified pollen from over 200 bees in 6 sites in Contra Costa County, CA. Using the pollen data with information about plant species, such as pollen available, protein from pollen and site availability, we used a rank-ordered logistic regression model to determine which factors most influence preference. Plant nativity is not a significant

factor in preference. Preference of plants is most commonly affected by nutritional aspects of the plants such as amino acid content and protein as well as availability of the resource.

TWO NEW SPECIES OF ROBBER FLIES OF THE TRIBE STICHOPOGONINI (DIPTERA: ASILIDAE) FROM REMOTE ISLANDS OF THE PACIFIC

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Abstract: We describe two robber flies (Diptera; Asilidae) species from islands of the Pacific in the genera *Clinopogon* 1847 Loew and *Stichopogon* Bezzi 1910, as new to science. The first is *Clinopogon* n. sp., reported from the Kwajalein atoll, Marshall Islands. This is the first record of the family Asilidae for the Marshall Islands. The second is *Stichopogon* n. sp., reported from Maupiti, French Polynesia. This is the first record of the family Asilidae for French Polynesia. Additional descriptions of *Clinopogon scalaris* Bigot, 1879 are also provided. A key to robber flies of the tribe Stichopogonini of the Pacific area is included.

RESISTANCE OF BAMBOO AND WOODS USED IN HAWAII TO ATTACK BY TWO SUBTERRANEAN TERMITES (BLATTODEA: RHINOTERMITIDAE)

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The Formosan subterranean termite, *Coptotermes formosanus* Shiraki, and the Asian subterranean termite, *Coptotermes gestroi* Wasmann, are pests of wood in service in Hawaii. We conducted two laboratory studies using the methods described in standard E1-09 of the American Wood Protection Association (AWPA 2009) to assess (1) the termite resistance of six bamboo species grown in Hawaii, with commercial potential for use in building materials; and (2) termite resistance of three commercially available wood species commonly used in construction in the islands. With bamboo, a no-choice laboratory assay was employed, in which termites of each species were exposed to a single wafer of the test material for four weeks (28 days). For the three commercial woods, a three-choice assay was used in order to simulate field conditions and assess termite feeding preferences. In both cases, termite mortality was recorded at the end of each test; and wood wafers were oven-dried and weighed before and after termite exposure to determine the mass loss due to termite feeding, and rated visually on a 0 (failure) to 10 (sound) scale. The most susceptible bamboo species with both termite species was *Guadua anguistifolia*, and the two bamboo species most resistant to termite attack were *Gigantocholoa pseudoarundinacea* and *Bambusa oldhamii*. Results of these tests will be useful in developing new locally-grown building materials for use under conditions of high termite hazard, for identifying wood species requiring preservative treatment before use, and for assessing behavioral differences between these two species that may impact prevention and control methods.

PREVENTING SPREAD OF INVASIVE SPECIES USING HEAT TREATMENTS AND IRRADIATION

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Disinfestation treatments of perishable commodities implemented at the origin or post entry can be very effective in preventing the establishment of alien pest species in an uninfested area. In the past, the chemical fumigant, methyl bromide, played an important role as an effective phytosanitary treatment. However, methyl bromide is considered an ozone depleter and a worldwide ban have been implemented on all uses. An alternative to methyl bromide are heat treatments and ionizing irradiation. Heat treatment has been used as thermal sterilization for nematode, fungal, bacterial and viral diseases and for insect disinfestation. Heat treatments benefit certain plants by increasing rooting, budding and vase life. Plants can be conditioned to tolerate heat treatments. Hot Water dip, drench and shower (45-50 C, 10-15 min) effectively disinfest plant materials of ants, aphids, caterpillars, foliar and root mealybugs, plant-parasitic nematodes, slugs, snails, scale insects, thrips, whiteflies. Hot air and/or vapor heat (39 - 44 C, 60-100% r.h. 1–3 hours) conditions plant materials to tolerate hot water with heat injury and used as treatment against thrips and other quarantine pests insects. Steam treatment of plant media by pasteurization or sterilization assures media free of arthropod pests, pathogens, nematodes, and weed seeds. Ionizing radiation at 150 Gy is an approved United States Department of Agriculture, Animal and Plant Health Inspection Service, quarantine treatment against tephritid fruit flies and 400 Gy for all other insects except Lepidoptera. This presentation reports that certain species of thrips, scale insects and mealybugs irradiated at 250 Gy will irreversibly damage its development and reproductive capacity. Tests conducted in Hilo, Hawaii indicates that certain tropical cut flowers and foliage, including floral ginger and ti-leaves, were tolerant to irradiation with no significant reduction in quality or vase life. Heat treatments and irradiation provides an effective phytosanitary treatment that will allow export of perishable commodities to major global markets without risk of invasive pest introductions.

DIET AND HOST ACCESS INFLUENCES SURVIVAL AND EGG PRODUCTION IN TWO TEPHRITID FRUIT FLIES

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We tested the hypothesis that protein and host deprivation would lead to different responses in how females prioritize between reproduction and survival in two tephritid species with differing demographic traits. Females of the Mediterranean fruit fly (*Ceratitis capitata*) and the melon fly (*Bactrocera cucurbitae*) were housed in group cages of conspecifics. At eclosion, flies were subjected to either a full diet (sugar + yeast derived protein) or to a sugar only diet. Flies started

on the sugar diet were either maintained on it until death or provided the full diet after a deprivation period. Host fruit timing and availability was manipulated so that females had constant, delayed or no access to an oviposition site. Denying both protein and host access was used to prevent egg production during the period of deprivation. Three trends were observed in both species: 1) dietary conditions affect survival and lifetime egg laying ability, 2) protein access at eclosion leads to a greater probability of survival and higher reproductive ability than when it is delayed, and 3) both mechanisms of delayed oviposition reduced lifetime reproductive ability, with the effect of host deprivation on survival and egg production being dependent on diet. In both species, protein availability is shown to be a requirement for somatic maintenance and gamete production; however, any period of protein deprivation reduces its benefits. The response to host deprivation was different for both species, with the melon fly showing a greater ability to cope with host scarcity and poor dietary conditions.

COARSE-SCALE SURVEY OF BUMBLE BEES (HYMENOPTERA: *BOMBUS*) ALONG SEVERAL HIGHWAYS OF BRITISH COLUMBIA AND THE YUKON TERRITORY, CANADA

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Bumble bees (Hymenoptera: *Bombus*) are the largest taxon of native bees found in temperate North America. Most bumble bee species are covered in dense pile, have large surface-to-area body ratios, and exhibit the ability for muscular thermogenesis. Combined, these adaptations allow them to fly at relatively low temperatures, reducing interspecific competition for floral resources and making them one of the most common floral visitors in cool climates. Despite their importance, relatively little is known about the distribution or community composition of bumble bees in the Province of British Columbia or Yukon Territory of Canada. We present sweep net data on bumble bees collected from these regions during late summer of 2010. Collections occurred in roadside habitats along Highway 97, the Yellowhead Highway and the ALCAN Highway. Hence, a vast area was sampled extending from N49° to N60°, and W137° to W118°. Data from one SE Alaska site is also presented. Preliminary analysis indicates that 207 specimens comprised of (a minimum of) 16 species were captured. The western bumble bee (*Bombus occidentalis* Greene]) was among these captures, a finding of great interest given the recent population declines of this species.

COMMUNITY COMPOSITION AND STRUCTURE OF TERRESTRIAL INVERTEBRATES IN AN ALTERED, LARGE-RIVER FLOODPLAIN OF NORTHERN IDAHO AND WESTERN MONTANA

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Large-river floodplains support a diverse array of habitats and a rich fauna, including terrestrial invertebrates such as insects and spiders. Although periodic flooding and inundation is critical for maintaining structural and functional elements of a floodplain, most rivers today are damned and their floodplains are unconnected from the river. Assessing losses in altered floodplains will require new approaches if mitigation or restoration efforts are to properly value, or restore, the ecological health of floodplain habitats. To this end, the Kootenai Tribe of Idaho is developing a multimetric, ecological indicator of floodplain ecosystem health, i.e. a Terrestrial Index of Biological Integrity (IBI). IBI development is simple in principal, requiring one to quantify the relationship between site condition and a suite of faunal metrics, then compiling the most predictive metrics into a single, predictive ecological indicator. Terrestrial invertebrates are a good fauna for use in IBIs because they are easily sampled and respond more quickly to environmental changes than vascular plants or vertebrate species. We present preliminary data on invertebrates collected with pitfall traps from a 160 km stretch of the Kootenai River floodplain of northern Idaho and western Washington, 2005 to 2009. Relevance for development of a floodplain IBI is discussed.

ORIGIN, BIOLOGY, AND TAXONOMY OF SWD – DO WE KNOW ENOUGH?

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In September 2008 fly larvae from damaged raspberries were sent from Santa Cruz County to the California Department of Fruit and Agriculture. They were identified as *Drosophila* sp. and declared harmless. Drosophilidae feed mainly on yeast in rotting fruit, and in fungi, but no report of damage in healthy fruits were known. Multiple reports of severe damage in cherries in 2009 aroused suspicion that the Western Cherry Fruit Fly (*Rhagoletis indifferens*) might be the culprit and the found *Drosophila* larvae are only secondary invaders. But soon it was clear that no *Rhagoletis* was present and not only cherry, but also other soft skinned fruits were infested. The identification to species level of Drosophilidae larvae is nearly impossible and the extracted DNA matched no species in the genetic databases. With the first available adults the species could be identified by morphological characters as *Drosophila suzukii.* The literature search revealed many fruit damage reports in Japan since the early 1930's, published mainly in Japanese. The original distribution of SWD is from northern India through Thailand and China up to Siberia and Korea. The presence in Japan might be caused by introduction at the turn of the century. The species was found in 2009, not only all along the west coast of North America, but also in Florida, Spain and France. The rapid spread of SWD in some areas and the slow spread in others is still not well understood.

ESTABLISHMENT OF SPOTTED WING DROSOPHILA IN THE WESTERN UNITED STATES AND IMPACT ON SMALL FRUIT CROPS

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Spotted wing drosophila (SWD) is a new exotic pest of soft-fleshed fruit crops in the Western United States. It is similar to other common species of *Drosophila*, except that females have a large ovipositor capable of penetrating and laying eggs into fruit prior to harvest. The result is maggot-infested or otherwise damaged fruit in the field that are rendered unmarketable. To date the greatest impacts of SWD have been in crops like raspberries, blueberries, cherries, strawberries and blackberries. Spotted wing drosophila was originally found in the fall of 2008 on California's Central Coast in areas where raspberries and strawberries are produced and by mid-year 2009 was well established in the Sacramento Delta where the majority of California's cherries are produced. By the end of 2009 SWD had become established throughout most of California, a large portion of Oregon, some of Washington, and in a few locations in British Colombia. Currently SWD is established throughout the Western United States in nearly all locations where host crops are grown. This paper will outline the movement of SWD throughout the West, the impacts it has had to blueberry and caneberry crops, and efforts that have been made to control it.

USING GENETIC MARKERS TO UNDERSTAND THE ORIGINS AND DYNAMICS OF BIOLOGICAL INVASIONS

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Genetic markers have proved to be powerful tools for the analysis of population genetic relationships in a wide range of organisms. Today, the term "genetic markers" applies almost exclusively to the analysis of DNA. Especially for studies of insects, the ability to directly analyze genetic markers at the DNA level has opened up a treasure trove of information about genetic variation found in individuals, populations and species. This variation is useful for understanding many processes such as biological invasions and the relationships between populations and species. In addition, the use of DNA for understanding these relationships brings in many other major advantages that are often not feasible using alternative approaches.
This presentation will focus primarily on the use of DNA based genetic markers to analyze biological invasions of the Mediterranean fruit fly, Ceratitis capitata, which occurred over an extended period of time relatively recently in California as well as other agriculturally sensitive areas around the world. Our analyses answered some, but not all, of the important questions regarding the dynamics of these populations.

In addition, I will describe how the analysis of DNA based markers extends to other areas including understanding the evolutionary relationships of populations and species in insect

studies. Finally, I will describe some powerful new technologies available for the analysis of DNA in insect species that will be of great value in a wide range of future applications.

PHEROMONE MATING DISRUPTION OF FILBERTWORM MOTH (*CYDIA LATIFERREANA)* IN COMMERCIAL HAZELNUT ORCHARDS

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Oregon supplies the United States with 99% of its hazelnuts. The key pest threatening commercial hazelnut orchards in Oregon is *Cydia latiferreana* (Tortricidae), filbertworm moth (FBW). Currently, most growers control FBW with one to two applications of Esfenvalerate (Asana XL), a broad-spectrum pyrethroid. Based on past success of using sex pheromone mating disruption to manage related tortricid pests, it was hypothesized that similar methods could be applied to FBW management. Two field research seasons were completed in 2009 and 2010 testing a synthetic sex pheromone in commercial hazelnut orchards located in the Willamette Valley region of Oregon. Ring and twin-tube dispensers containing a synthetic component of FBW sex pheromone were placed in two orchards at three densities (high, low, and untreated control). Delta traps containing septa of the compound at two strengths (1x and 10x) were placed in each test plot. Significantly higher mean FBW per trap counts were found in control plots versus the treatment plots in both orchards in 2009 and one orchard in 2010. Nuts examined for infestation of FBW were all below the industry rejection threshold. Sex pheromone mating disruption is a promising option for filbertworm management in Oregon.

LARVAL MOSQUITO CONTROL AS PART OF INTEGRATED MOSQUITO MANAGEMENT

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Integrated mosquito management programs strive to minimize negative environmental impacts while reducing adult mosquito population densities to levels that reduce pestiferous activity and/or disease transmission (Floore 2006). The restriction of immature stages of mosquitoes to bodies of water makes surveillance and control of these stages easier than control of adults. Strategies include the use of bacterial sprays, insect growth regulators, mermithid nematodes, oils, chemical larvicides, and a variety of invertebrate and vertebrate predators as well as source reduction and surveillance. Given the variety of methods that can be employed, creating a program that uses these in compatible and effective ways in appropriate environments can be difficult. A historical review will be presented that covers the contributions of graduate students to the current practices of larval mosquito control as a part of current integrated mosquito management programs. A critique of these contributions will be given, and I will explore how recent California graduate student research will impact the future of larval mosquito control.

USING PHOTOGRAPHS TO ESTIMATE MOSQUITO LARVAL ABUNDANCE

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Determination of larval mosquito densities is important in determining the best methods for larval mosquito control. Improper visual estimates due to inexperience or lack of calibration may lead to overrepresentation or underrepresentation of the true population. Additionally, determining predation rates by the use of instantaneous visual estimates can be difficult since the predator could continue to feed during the estimate. Here, I examine the use of photographs as a method of replacing visual estimates. Using a random number generator, four participants estimated the number of fourth-instar *Culex quinquefasciatus* larvae in a 10-gallon aquarium filled with 15 L of distilled water. Participants were given 30 seconds to assess the number of mosquitoes in 10 different trials. Participants varied in their experience estimating larval mosquito populations from 2- 25 years. Photographs were then taken of each trial using a digital point-and-shoot camera from above. The images were examined, counted and compared to the visual assessments. These results were accounted for in the development of a predator efficiency protocol.

INFLUENCE OF MAIZE MOSAIC VIRUS ON THE FITNESS OF *PEREGRINUS MAIDIS*

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The corn planthopper, *Peregrinus maidis* (Ashmead), is a serious corn pest throughout many subtropical and tropical regions around the world and is the vector of the corn virus, *Maize mosaic virus* (MMV). The virus replicates and persists throughout the entire life span of the planthopper. In the field, nymphs are observed developing on infected host plants inoculated by the parental generation, and therefore are exposed to the virus soon after birth. It is yet to be determined whether MMV has a beneficial or negative impact on its vector. Here, we examine the influence of MMV on the fitness of *P. maidis*. We compared the development, fecundity, and longevity of planthoppers feeding on MMV-infected versus healthy corn leaves. First instar nymphs were placed individually into small glass culture tubes (12x75mm) containing either healthy (non-infected) or MMV infected susceptible corn leaf cuttings. Insect fecundity was monitored by placing paired adults into glass culture tubes (13x100mm) with healthy leaves. Pairs were transferred to new tubes with fresh leaves daily. Our results show no significant difference in mean developmental time from first instar nymphs to adults (days), mean fecundity (Eggs/♀/day), and mean longevity (days). These findings suggest no detrimental effect of MMV to its planthopper vector.

MATING DISRUPTION OF NAVEL ORANGEWORM: RESULTS FROM FIVE YEARS OF AREAWIDE CONTROL

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Research on the use of mating disruption (MD) for navel orangeworm (*Amyelois transitella*) control has demonstrated that significant damage reduction can be achieved in both large scale area-wide settings and in smaller 50-150 ac plots, using the major female sex pheromone component, ((*Z*,*Z*)-11,13-hexadecadienal)), dispensed from low density, high emission devices (puffers). This technique is now available and used commercially in almonds with positive results. This poster outlines our approach to implementing mating disruption programs in two large "Areawide" control sites located in Kern County, and the results of integrating sanitation, mating disruption and some insecticide use on crop damage from NOW.

HISTORIC LINKS: THE FIRST GOLF COURSE IN SOUTHERN OREGON AND TREE FRUIT PEST MANAGEMENT

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In 1911, a group of Rogue Valley tree fruit growers created the first golf course in southern Oregon. Each of the nine holes was named after a pest of pears or apples. The nine pests bestowed with this honor included six insects, two diseases and one mite. In order, the pests comprising the nine holes were: Wooly Aphis, Thrips, Anthracnose, Blight, Scale, Slug, Borer, Blistermite, and Codling. This list of pests provides insight into which pests were considered to be the most important in southern Oregon orchards one hundred years ago. Insecticide use at this time was limited to lead arsenate, mineral oils and nicotine. It is notable that of the three arthropod pests currently considered to be the most important: codling moth, pear psylla, and twospotted spider mite; only codling moth was a top pest in 1911. However, that state of affairs is easily explained since pear psylla was not present in the Pacific Northwest at that time and spider mites are a classic example of an induced pest, only becoming a serious problem in tree fruit after World War II following the introduction of DDT and other broad spectrum insecticides. More interesting is the fact that some of the pests of 1911 are once again becoming problems as new insecticides which are not as broad spectrum are being used more frequently. Specifically, populations of woolly apple aphid and scale have increased in recent years, and outbreaks of blistermite and pear slug have also been observed.

SELENIUM'S IMPACT ON THE POLLINATION ECOLOGY, LEARNING AND SURVIVAL OF *APIS MELLIFERA* (HYMENOPTERA: APIDAE)

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Selenium (Se) from agricultural runoff has contaminated areas of the central valley of California where insect pollination can be critical to the functioning of both agricultural and natural ecosystems, yet we know very little about how soil-borne pollutants such as Se can impact pollinators such as the honey bee (*Apis mellifera* L.). We conducted a semi-field experiment using Se-treated radish (*Raphanus sativus* L.) to quantify floral traits and honey bee foraging visits. Floral morphology and total flower number were not altered in radish plants irrigated with Se concentrations comparable to those found in polluted soils. Se-treated plants remained attractive to honey bees and were not pollen limited. In an olfactory learning assay, the effects of Se on short term memory in honey bees were tested. Bees fed 0.3 mM Se as selenate (the average concentration of Se found in greenhouse-grown radish) showed a significant reduction in acquisition and overall response to both trained and novel odors immediately after training and 24 hours later. Se may reduce the honey bee's overall ability to respond to and differentiate odor stimuli. In a laboratory mortality assay, honey bee foragers were fed 5 chronic dosages of Se as selenate or selenomethionine, or sulfur (S) as methionine. Selenate significantly increased mortality in a dose-dependent manner starting at the 0.3 mM concentration. If honey bee foragers repeatedly visit a Se-accumulating plant such as radish, the chronic exposure to Se may impact the survival of the worker population.

INTERNATIONAL BIOLOGICAL CONTROL RESEARCH AT THE USDA-ARS OVERSEAS BIOLOGICAL CONTROL LABORATORIES

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USDA ARS program priorities have traditionally included emerging diseases and invasive weeds and arthropods in addition to supporting research on established pests of plant and animal protection. International research is often necessary to effectively address invasive species, especially in situations where biological control strategies are utilized to help manage these species.

The USDA-ARS maintains overseas biological control laboratories (OBCLs) in France (Montferrier-sur-Lez), Argentina (Hurlingham), Australia (Brisbane), and China (Beijing) to provide support for biological control programs conducted by ARS and cooperating institutions and which involve foreign-based research on invasive pests. Cooperating U.S. institutions include other federal agencies, state agriculture departments and universities. International collaborations are conducted with foreign government and nongovernmental agencies and universities. The primary role of OBCLs is to discover and characterize the natural enemies of invasive weeds and pests, to study their effectiveness and host specificity in their region of origin, and to supply these agents to cooperating scientists in the U.S. and elsewhere for further research and implementation. Associated research often includes collaborative molecular genetics and taxonomic studies.

In addition to a wide range of OBCL projects on invasive species of primary importance as pests in North America (for example, recent and current projects include imported fire ants, wheat stem sawfly, brown marmorated stink bug, soybean and Russian wheat aphid, yellow star thistle,

tamarisk, water hyacinth, *Lygodium* fern, giant cane reed), there are also projects with broad international scope & partners (e.g., sweet potato whitefly, olive fruit fly, Asian longhorned beetles, citrus psyllid), projects to manage pests & diseases of foreign crops important to U.S. markets (e.g., coffee berry borer, cacao black pod disease) and international assistance projects on North American species which have become invasive elsewhere (e.g., *Metcalfa pruinosa*, silverleaf nightshade). New areas of USDA emphasis to promote research on the impact of climate change on agriculture and other aspects of international food security may offer additional opportunities for international research at the ARS international laboratories.

THE RECURRING TEPHRITID OUTBREAKS IN CALIFORNIA: INSIDER'S PERSPECTIVE

Kevin M. Hoffman

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Beginning in 1954, there have been at least 18 exotic tephritid species detected in California. The rate of detection of new species has been relatively constant, with two in the 1950's, three in the 1960's, one in the 1970's, seven in the 1980's, three in the 1990's, and two in the 2000's. The pattern that has emerged in the last 20 years is that four species/species complexes have dominated the detections by being detected every year or nearly every year, often in more than one location. These four are *Anastrepha ludens* (Loew), *Bactrocera correcta* (Bezzi), *Bactrocera dorsalis* (Hendel) complex, and *Ceratitis capitata* (Wiedemann). Despite this introduction pressure, none of these species are known to have become permanently established in the State. This success is the result of an effective system of early detection and rapid response, which includes area wide control options. In contrast, a species first found in two counties in 1998, *Bactrocera oleae* (Gmelin), has now been detected in 47 of California's 58 counties. Permanent establishment of this species was made possible by inadequate detection targeting of its host, a lack of a specific lure, and the lack of an area wide control option.

KEEP YOUR FRIENDS CLOSE AND YOUR ENEMIES CLOSER: RECENT PROGRESS IN STUDIES OF BEHAVIORAL ECOLOGY OF INVASIVE PREDATORS IN HAWAII

Brenden Holland

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Many biologists are drawn to live and work in the Hawaiian Islands thanks to spectacular levels of endemism and biodiversity, driven by extreme isolation and diversity of microhabitats. But due to the devastation of native species by habitat loss and release of invasive predators, evolutionary biologists are often compelled by necessity to transition into the field of conservation biology. With the same number of species of land snails as all of North America, the Hawaiian Islands harbor a disproportionate level of snail biodiversity, which is under assault by direct predation. During this talk I will focus on my lab's recent efforts to improve our understanding of the tracking and foraging behavior of two different invasive predators on native invertebrates, the wolf snail, *Euglandina rosea*, and the Jackson's chameleon, *Chamaeleo*

jacksonii xantholopus. We are seeking data that will ultimately help us devise control and or eradication strategies for these invasive pests.

GREEN PEACH APHIDS IN POTATOES: FIELD POPULATIONS AND MANAGEMENT IN PROSSER WASHINGTON

Erin N. Hollingbery, Keith S. Pike, George Graf, and John Wilson

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

Green peach aphid (GPA), *Myzus persicae* (Sulzer), is a perennial threat to Washington State's potato industry. It makes up about 99% of the aphids that feed on potatoes, and by virtue of its abundance and efficiency in transmitting viruses, is the main aphid of concern. Revenue losses attributable to viruses transmitted by GPA can be significant. Average losses in processed tubers due to aphid-transmitted potato leafroll virus (PLRV) are estimated at 10%, but can reach levels of 25% or higher in fields subject to heavy GPA infestation.

Currently growers are being forced by external socioeconomic forces to move rapidly from a pest management approach based largely on zero tolerance, calendar sprays to a more risk-based mitigation approach where pest monitoring, carefully targeted chemical treatment and natural enemy conservation is the norm. Comparative performance data from 2010 replicated field work will be presented for chemically-intensive management (foliar application of broad-spectrum organophosphate, carbamate, neonicotinoid and pyrethroid insecticides, applied as often as every 7-10 days on a calendar bases following first detection of aphids), single seed-applied neonicotinoid, and untreated controls. Results to date show that aphid levels in plots subject to frequently applied broad spectrum insecticides (standard industry approach in years past) caused no significant reduction in aphid numbers compared with the untreated checks. In contrast, the single seed-applied neonicotinoid treatment significantly held aphid densities at low levels for the full growing season. This latter approach is already being adopted by Washington growers, and is expected to become the industry standard for managing green peach aphids in potatoes in Washington.

BELEAF®, A NEW CLASS OF INSECTICIDE FOR PIERCING AND SUCKING INSECTS WITH SOFT ACTIVITY ON BENEFICIALS

Robert Hooten, Leland W. Learned, Curtis Sandberg, and Robert Leifker

FMC Corporation, 1735 Market Street, Philadelphia, PA

Beleaf® is composed of the active ingredient, flonicamid. Flonicamid is a Group 9C selective feeding blocker pyridinecarboxamide class of chemistry. Recent MRL's from Canada opens up new crop uses in the United States on brassica vegetables, cucurbit vegetables, fruiting vegetables and leafy vegetables. Beleaf is also labeled for use on pome fruit, stone fruit, root vegetables, and tuberous and corm vegetables. The soft activity of Beleaf on beneficial insects allows the use on these crops during bloom for aphid and plant bug control. Beleaf is a very

effective insecticide tool that growers can use to help manage resistance issues and maintain beneficial insects on several crops.

STALLION®, AN INSECTICIDE OFFERING WITH TWO MODES OF ACTION TO HELP PREVENT INSECT RESISTANCE IN SEVERAL CROPS

Robert Hooten and Leland W. Learned

FMC Corporation, 1735 Market Street, Philadelphia, PA

Stallion® is composed of two active ingredients, zeta-cypermethrin (a cyano pyrethroid) and chlorpyrifos (an organophosphate). These two actives were combined in an optimized ratio using state of the art formulation technology to allow use on several crops without having to post the fields. Stallion has shown excellent insect activity along with increased yields versus currently registered products. Having the ability to utilize two modes of action will also help reduce the potential of resistance development.

THE EFFECT OF SEX RATIO ON COPULATION, SPERM TRANSFER, AND SPERM RESERVES IN A WATER STRIDER

Clayton Houck and Daphne Fairbairn

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Past studies have had difficulty predicting the effect of increased mating opportunities on male behavior and sperm reserves. Although male reproductive success increases with additional copulations and the transfer of numerous sperm and large sperm to females, these may reduce male sperm reserves and affect future reproductive effort. The water strider *Aquarius remigis* Say (Gerridae, Heteroptera) has large sperm (5mm length), copulates frequently (averages one per day) and has a polygynandrous mating system with sperm competition. We test the hypothesis that sperm reserves will decrease as mating opportunities increase by comparing the behavior and sperm reserves of male *A. remigis* after nine days under three sex ratios (3 males:9 females, 6 males:6 females, 6 males:0 females) and for single copulation trials with two sex ratios (1 male:3 females, 2 males:2 females). We show that males with additional mating opportunities copulate more often and for shorter durations but frequently have copulations of insufficient duration to result in sperm transfer (copulations <15min do not result in sperm transfer). Males have an average of 14,611 sperm in their seminal vesicles but transfer an average of only 1,695 sperm per successful copulation. Thus, they transfer only a fraction of their sperm reserves in any given copulation and do not become sperm depleted, even when the sex-ratio is highly female-biased. Number of sperm transferred was not related to either copulation duration or sex ratio, suggesting lack of strategic sperm allocation by males. Multiple mating did not influence the number of sperm in the female reproductive tracts and did not increase female fecundity or fertility. Therefore, non-virgin females appear to gain no direct benefit from additional sperm transfer, although past research shows females *in copula* receive less harassment from males. We argue that significant variation among treatments in the proportion of successful copulations and the duration of copulations can best be explained by

significant female influence over copulation duration and sperm transfer, rather than by variation in male reproductive tactics.

THE BIOLOGY, ECOLOGY AND CONTROL OF VELVETY TREE ANTS (*LIOMETOPUM* SPP.)

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There are three North American species of *Liometopum*, also known as velvety tree ants: *L. apiculatum* Mayr,, *L. luctuosum* Wheeler, W.M, , and *L. occidentale* Emery. *L. luctuosum*, and *L. occidentale* are found in the western U.S., and reportedly cause structural damage [1]. Both species are often mistaken for carpenter ants and odorous house ants by homeowners and Pest Management Professionals (PMPs), and consequently little is known about their incidence and importance as structural pests [2].

The summer of 2010 I initiated a study to determine the food preference of one species of velvety tree ant, *Liometopum occidentale*. Feeding preferences were determined using laboratory and field choice tests. Pre-weighed vials of different types of foods were placed within a foraging arena near the ants foraging trials. An arena designed by Rust et al. [3] was used to determine feeding preference in the field. A variety of solid and liquid foods that contain sugars, fats, and/or proteins were screened using this method. Laboratory choice tests were conducted using a scaled-down version of the arena used in the field trials, to screen for preferred concentrations of foods. The methods and results of these studies will be discussed.

The goal of this research is to develop an effective Integrated Pest Management (IPM) program specifically designed for velvety tree ants that incorporates a baiting program. Currently, PMPs are applying perimeter sprays of fipronil (Termidor®) or bifenthrin (Talstar®) for control. Although effective, this approach is not target-specific and may be contributing to environmental contamination of urban waterways. Baits are more target-specific and environmentally friendly than broadcast sprays.

DEADLY AMBROSIA BEETLES: SUDDEN EMERGENCE OF PATHOGENICITY IN INSECT-FUNGUS SYMBIOSIS AND A CATASTROPHIC FUTURE FOR NAÏVE FOREST ECOSYSTEMS

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Invasive ambrosia beetles (23 spp. in the US in 2010) are emerging as a new and currently uncontrollable threat to forest health and fruit industry throughout the US. While some exotic ambrosia species become major pests and tree-killers, or spread with rate unmatched by any native species, others remain inconspicuous members of the forest insect community, or entirely fail to establish despite repeated introductions. In this project we will test which features of exotic ambrosia beetles are critical for successful invasion and establishment, and whether a major role is played by their fungal symbionts, the true agents of tree mortality. Our approach, which combines the largest existing datasets on scolytine distribution with next-generation

sequencing of mycangial fungi, will allow us to address three major unknowns of the ambrosia symbiosis: 1) What is the real global fidelity between the beetle and fungus symbionts? 2) Do invasive beetles spread novel phytopathogens on new continents? 3) Why are some ambrosia beetles so successful worldwide, while others remain rare even on their native continents?

VIRULIFEROUS AND NONVIRULIFEROUS APHID RESPONSES TO *BARLEY YELLOW DWARF VIRUS*-INFECTED PLANTS

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Barley yellow dwarf virus (BYDV) causes one of the most devastating diseases of cereals worldwide. BYDV is transmitted by aphids in a persistent circulative manner. The bird-cherry oat aphid (BCOA), *Rhopalosiphum padi* (L.), is an important vector of BYDV-PAV. Increased understanding of virus, plant, and vector interactions could improve disease management. Recent research showed nonviruliferous BCOA prefer BYDV-infected compared to virus-free wheat and that changes in virus-induced volatiles of plants mediate this response. Our objective was to examine simultaneously host plant preferences of viruliferous aphids (reared on BYDV-infected plants) and nonviruliferous aphids (reared on virus-free plants). Assays were conducted using winter wheat plants (var. Lambert) that had been inoculated with BYDV (using viruliferous aphids) or sham inoculated (using nonviruliferous aphids). Plants were seeded simultaneously and bioassays conducted 40-46 days after inoculation. Aphids were exposed to the entire suite of host plant selection cues during bioassays. Viruliferous and nonviruliferous aphids were released simultaneously into separate arenas containing a single leaf attached to an intact plant from each plant-inoculation treatment, and monitored every 12-hrs for 72 hrs. A significantly greater proportion of nonviruliferous aphids responded to plant cues compared to viruliferous aphids either because they are less mobile or less discriminating. Nonviruliferous aphids showed a significant preference for BYDV-infected plants while viruliferous aphids preferred virus-free plants. This shift in preference from infected to noninfected plants following virus acquisition could accelerate the rate of virus spread. Ongoing work aims to determine the mechanisms causing these changes in aphid behavior and implications for virus spread.

DRONE BROOD REMOVAL: A TOOL FOR MANAGING *VARROA DESTRUCTOR* IN *APIS MELLIFERA* COLONIES IN HAWAII.

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Varroa destructor is considered to be one of the most serious pests of *Apis mellifera*. Upon the discovery of the mite on Oahu and on the Big Island, local beekeepers are searching for treatments that suit our subtropical climate and floral regimes. We tested the efficacy of drone brood removal (DBR) as a control method of varroa mite populations. Varroa mites are naturally more attracted to drone brood than worker brood. Therefore, it is possible to attract, trap, and

remove mites using an artificial frame that stimulates the construction of drone cells. We conducted our study at two separate apiaries where honeybees are kept in 10 frame Langstrof hives. In apiary A, 16 colonies were randomly assigned to DBR, while 6 DBR colonies were monitored in apiary B. Because the effectiveness of the drone comb treatment relies on 2 variables: drone abundance and varroa mite infestation levels, we recorded how these variables changed throughout the season for each hive. In spite of the relatively close proximity between the two study sites, there were inter-apiary differences in drone production: Apiary A had a decrease in drone production during the winter months while Apiary B had relatively high and continuous drone production during the study period. The percent of mite infested drone cells was inversely related to drone abundance in both apiaries. Our results suggest that drone comb trapping could be used as part of an Integrated Pest Management program designed to control *Varroa destructor* in *A. mellifera* colonies in Hawaii.

FRUIT FLIES USED AS CARRIERS OF MOTH PHEROMONE FOR MATING DISRUPTION CONTROL TECHNIQUES

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Conventional mating disruption technique using pheromone dispensers has been shown to be an effective control method on various moth pests. In an attempt to increase the efficiency of distribution of pheromone, this research reports the results of mobile mating disruption of two moths, light brown apple moth, *Epiphyas postvittana* and the stinging nettle caterpillar moth, *Darna pallivitta*. Mediterranean fruit flies were fed light brown apple moth pheromone in honey and melon flies were fed nettle moth pheromone with honey and released in field plots with traps containing pheromone septa. Responses to pheromone traps were recorded as an indirect measurement of mating disruption. Live female light brown apple moths were also placed in one-way traps and placed in the field for 24 hours after the flies were released. Trap orientation and mating were significantly lower in the treatment fields with pheromone fed flies. Fields that had no flies released had significantly higher trap captures and more females mated in one-way traps. Further research will look at utilizing other insect carriers.

PROSPECTS FOR AREA-WIDE MANAGEMENT OF CBB IN HAWAII

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Initial perspectives from coffee growers, processors and even consumers at the news that coffee berry borer (CBB) had been found in “kona” coffee ranged from fear that Hawaii-grown coffee was dead to thoughts that through eradication the coffee could be again made CBB-free. These initial reactions to the news of invasive species is predictable and has followed similar reactions by growers and the public to the introduction of light brown apple moth and glassy wing sharpshooter into California. Interestingly, Hawaii is not the first place to get CBB and in fact is one of the last coffee-growing areas to be invaded by this pest. Luckily, this has resulted in a

significant body of information being developed world-wide on the biology, and management of this beetle.

From a practical and research perspective, CBB control will require a concerted area-wide approach similar to the recent successful program on tephritid fruit flies here in Hawaii. Area-wide approaches are becoming more widespread as farm-by-farm has proven elusive. Sustainable management will require groups of growers in an area to apply measures such as sanitation, trapping, chemical controls, biological controls and postharvest measures to successfully deal with this pest. Knowledge of the specific parameters under which these measures will be effective will need to be refined for Hawaii-specific conditions. However management of this pest is possible if the area-wide approach is implemented.

UNDERGRADUATE EXPERIENCES IN ARS RESEARCH LABS: PERSPECTIVES AND OPPORTUNITIES

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Experiences for undergraduates at ARS research labs vary with locations, programs and individuals. Many ARS labs have interactions with undergraduates where scientists function as mentors for projects or present talks at University courses. Undergraduate students are also hired to work in federal labs under a variety of authorities. The most common being the 'Research Support Agreements" (RSA), where the university employs students to work at federal labs under a specific agreement and two federal programs, the "Student Temporary Employment Program (STEP), and the Student Career Experience Program (SCEP). The main difference between these two programs is that under the SCEP program students can be hired non-competitively into permanent positions if available. Both federal programs as well as the RSA programs are focused a great deal on the student in the work environment with learning as a secondary consequence of the work experience. Still, students who have been employed under one or more of these programs have "learned" from their experience…..both good and bad. We present a few perspectives from actual student interviews on their experience in the federal workplace. While each might be unique they all appreciated the opportunities and contacts that they were afforded by the experience.

FROM AFRICA WITH LOVE

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Coffee (mainly *Coffea arabica* and *C. canephora*) is the world's most valuable tropical export crop, on which more than 100 million people in these regions depend for their livelihood. However, the yield of coffee beans is severely affected by its main pest, the coffee berry borer *Hypothenemus hampei* (Curculionidae). Infestation levels can be as high as 90%, and annual losses worldwide exceed US $500 million. The origin of *Hypothenemus hampei* is still unknown,

but it was first described in 1867 in France feeding on dry coffee beans of unknown origin. Subsequently, *H. hampei* has spread to all coffee producing countries worldwide except China and Nepal. The most recent accidental introduction was reported in the Kona area of Hawaii. Here we report on an extensive multidisciplinary 5 year-long study in East Africa, which objective is to trace back the origins of the pest and understand its biology, ecology and biological control in its native range. Novel alternatives to manage the pest are discussed. Additionally, recent research developing molecular approaches to study predator-prey interactions in coffee will be discussed, and the utility of the approaches highlighted in relation to understanding the dynamics of coffee berry borer biological control in Hawaii.

BEAUVERIA OR OTHER FUNGI: TOOLS TO MANAGE COFFEE BERRY BORER, NOT MAGIC BULLETS

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The insect pathogenic fungi, especially *Beauveria bassiana* and *Metarhizium anisopliae*, have undergone much development as biological insecticides (mycoinsecticides) in recent years. Of the 110 fungus products on the worldwide market, 79% represent these two species. Several *Beauveria*-based products are used in Latin America for control of Coffee Berry Borer (CBB), and there has been considerable recent interest in Puerto Rico and Hawaii about using this fungus to halt the invasion of CBB. These fungi can be effective, but are not "magic bullets." They have limitations and must be used carefully and knowledgeably, within an integrated management system, to extract maximum value. In my talk I will cover basic biology and ecology of *Beauveria* as they affect efficacy and considerations in its use against insects, esp. CBB.

EFFECT OF RADIO FREQUENCY TREATMENTS ON COWPEA WEEVIL ADULTS

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Dried pulses (chickpeas, lentils and dried peas) are valuable export commodities in the US Pacific Northwest. Postharvest infestation by stored product insect pests such as the cowpea weevil may cause importing countries to require phytosanitary treatments before shipment. Typically, chemical fumigants are used to disinfest dried pulses, but the industry is exploring non-chemical alternatives. One possible alternative is the use of radio frequency (RF) energy to rapidly heat product to insecticidal levels. Preliminary studies have showed that although cowpea weevils are more heat tolerant than other tested postharvest insects, RF treatments coupled with 60°C hot forced air should provide adequate control. However, one issue that must be addressed is the possible escape of active cowpea weevil adults as product heats during RF treatments. This paper examines the behavioral and mortality response of adult cowpea weevil to sudden high temperatures. Adults were observed to attempt to escape temperatures of 40-45°C, and reached

heat stupor at temperatures of 56-60°C. Complete mortality of adults was obtained after exposure to 60°C for 25 seconds. Combinations of RF and 60°C hot forced air did not allow adults to escape the treated product. Adults present on the surface of the treated product moved into the product, apparently to avoid the hot air, and were eventually killed as RF energy heated the product to lethal levels. Thus, RF treatments using hot air should effectively control cowpea weevil in dried pulses.

THE EXCEPTIONAL CASE OF THE LANTANA LACE BUG, *TELEONEMIA SCRUPULOSA*

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The lantana lace bug, *Teleonemia scrupulosa* (Hemiptera: Tingidae), was introduced to Hawaii for biocontrol of *Lantana camara* (Verbenaceae) in 1902 and again in 1954. Among 43 cases of non-target native plants used as hosts by weed biocontrol agents in the US and Caribbean in the past century, all appear predictable with the exception of this lace bug. In Hawaii, *T. scrupulosa* is known to develop on *Myoporum sandwicense* (Myoporaceae), a very distant relative in the same order as lantana, Lamiales. Biocontrol efforts using *T. scrupulosa* proliferated around the world following its first use in Hawaii, and a few additional instances of non-target host use by this lace bug have been documented, but its host range appears to remain limited and highly disjunct. Possible genetic differences in host specificity among Hawaiian populations of *T. scrupulosa* were investigated in retrospective greenhouse tests. Ovipositional host specificity did not vary among populations, but was consistently disjunct, suggesting a genetic pre-adaptation for selecting a specific subspecies of *M. sandwicense* as a host. However, adaptation for development on *M. sandwicense* also appears to have occurred in the population collected from this plant. Additional studies are needed to determine the basis for host specificity in this insect and whether new protocols for host range evaluation may improve our powers to predict such non-target interactions.

INVASTIVE SPECIES SITUATION IN CALIFORNIA NURSERIES AND LANDSCAPES

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The nursery and landscape industries are closely tied to new construction, commercial, and residential property sales transactions. The nursery industry is also dependent on sales to retail nurseries and the large box stores such as Home Depot and Lowes. For many production nurseries this makes up a large percentage of their sales and is a market that does not allow them to pass on the costs of complying with quarantine regulations or increased pest control costs. Economic studies have helped to estimate the cost of several of the major insect pests to the nursery industry and until the recent recession, the costs were a burden but not devastating. A large production nursery estimated that the Glassy winged sharpshooter shipping protocols

required to deliver GWSS host plants from southern California to northern California were about 10% of the cost of production (personal communication). However, the current recession, quarantine boundaries creating an uneven playing field, changes in marketing such as pay by scan, bad weather, loss of sales, and difficulty obtaining loans from the banking industry have exacerbated the impact of any increase in costs because of invasive insects. Recently, several California production nurseries have gone out of business or declared bankruptcy and any additional costs of doing business have the real potential of threatening the existence of nursery and landscape companies.

California nurseries and landscapes continue to be infested by invasive species that trigger costly quarantines or require the industries to live with an additional pest after its regulatory status has been reduced. Since the 1990's, California has been invaded by destructive and costly pests such as the Red imported fire ant, Glassy winged sharpshooter, Diaprepes root weevil, Asian citrus psyllid, and Light brown apple moth. Other insect pests such as the Ash whitefly, Giant whitefly, Citrus leafminer, Eucalyptus long horned borers, Eucalyptus tortoise beetles, Red gum lerp psyllid, Nantucket pine tip moth, Eugenia psyllid, Olive fruit fly, Olive psyllid, Tipu psyllid, Bagrada bug, and Myoporum thrips were not considered important agricultural pests. The nursery and landscape industries were left to carry the burden of the costs of control, shipping cleanliness standards, and the hope that a biological or chemical control could be found for the pest. Most recently, a localized infestation of the Red palm weevil was found in Laguna Beach, California and quarantine decisions by United States Department of Agriculture (USDA) and the California Department of Food and Agriculture (CDFA) are pending.

Because of its climate, international trade and tourism, California will continue to be plagued by invasive pests. The nursery industry will be regulated because of its potential to quickly spread pests over long distances and the landscape industry in the densely planted and diverse landscapes of California will continue to serve as a breeding ground for invasive pests. The nursery and landscape industry more than ever will depend on exclusion, harmonization of quarantine protocols when possible, effective biological and chemical control programs, and careful consideration of not only biological but also economic information in developing quarantine protocols and boundaries.

MANAGEMENT OF ALIEN PREDATORS TO PROTECT PARK RESOURCES

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The Resources Management Division at Haleakalā National Park controls various non-native predator and pest species that threaten natural resources. Predation by introduced mammals such as feral cats, mongooses and rats is one of the major limiting factors for native Hawaiian species including the endangered nēnē (Hawaiian goose) and 'ua'u (Hawaiian petrel). The Western yellowjacket, *Vespula pensyvanica* (Saussure), is an introduced wasp that is a pest to humans as well as a threat to native arthropods. Resource managers at Haleakalā National Park have taken an integrated approach to control these alien species. Field staff are trained in predator control, yellowjacket control, and endangered bird monitoring. We found that having staff trained in a variety of management tasks is efficient, allowing us to complete multiple tasks in a given field location.

PRE AND POST RELEASE MONITORING OF *EURYTOMA ERYTHRINAE* AND GALL WASP POPULATIONS ON EXOTIC *ERYTHRINA* SPECIES IN HAWAII

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The Erythrina Gall Wasp, *Quadrastichus erythrinae* Kim (Hymenoptera: Eulophidae), was accidently introduced to Hawaii in 2005 and quickly spread throughout the state infesting all stands of the endemic wiliwili along with exotic *Erythrina* species grown in botanical gardens, urban landscape and agricultural settings. In November 2008 *Eurytoma erythrinae* (Hymenoptera: Eulophidae) was approved for released. We report results from pre and post release monitoring of gall wasp populations on 16 species of exotic *Erythrina* on Kauai, Oahu and Big Island.

AN EXTRAORDINARY RADIATION OF HAWAIIAN PURSE-CASED HYPOSMOCOMA (LEPIDOPTERA: COSMOPTERIGIDAE)

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The spectacular Hawaiian moth genus *Hyposmocoma* includes more than 350 described species endemic to the Hawaiian archipelago. The total number of species may be greater than the radiation of *Drosophila*, as nearly every species is endemic to a valley or volcano. Unlike most cosmopterigids which are typically internal feeders of leaves, seeds and stems, *Hyposmocoma* has extraordinary life-histories and behavior, as some are known to be carnivorous, feeding on snails, while others are amphibious and can live under water. The genus is also unusual among Lepidoptera in that their larvae create protective "cases" in which they survive. An extraordinary morphological diversity of case types exist, and thus far, more than ten different types have been identified. The present study focuses on the "purse" case type, a group thought to be ancestral to other case types, such as the burrito and cone cases forms. Maximum likelihood and Bayesian molecular phylogenies indicate that the purse case evolved independently at least twice in the genus. Each purse clade is monophyletic and strongly supported with high bootstrap values and posterior probabilities. We tentatively call these two monophyletic groups the "flat purse" and the "tubular purse" types, and discuss the evolution and biogeography of purse cases on the Hawaiian Islands.

MICROBIAL CONTROL OF THE INVASIVE *DIAPREPES*, A ROOT PEST OF ORNAMENTALS

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The Diaprepes root weevil, *Diaprepes abbreviatus*, was discovered in southern California 2006 in San Diego County and then subsequently in Los Angeles and Orange Counties and is a major threat to citrus orchards, landscape plants and nursery production. This exotic pest probably came into California in infested ornamental plants from Florida. It has over 270 plant species in 59 plant families as hosts with the larval stage spending 8 to 12 months feeding on roots. In Florida, entomopathogenic nematodes have been effective in controlling this insect attacking citrus roots in sandy soils.

In California, we evaluated the entomopathogenic nematode, *Steinernema riobrave*, and the entomopathogenic fungus, *Metarhizium anisopliae*, against *D. abbreviatus* to determine whether they can provide complete control of larvae in containerized plants in California nurseries. The objective was to have entomopathogens as alternatives to chemical pesticides as eradication tools for this invasive insect in containerized plants so they could be shipped statewide to non-infested area. A series of experiments were conducted in a quarantine facility testing the efficacy of *S. riobrave* alone, *M. anisopliae* alone, or the combination of *M. anisopliae* and *S. riobrave* against *D. abbreviatus* larvae in a soilless medium containing an Indian hawthorn plant. The nematode provided good, but not complete control using standard methods of application. *M. anisopliae* was not effective in controlling *D. abbreviatus* and further seemed to have an antagonistic interaction when combined with the nematode. We conclude that both entomopathogens cannot be used to eradicate *D. abbreviatus* from containerized plants. However, if the invasive *D. abbreviatus* becomes established statewide, *S. riobrave* could be used in suppressive programs in California nurseries.

ASSESSING IMPACTS OF AN INVASIVE THRIPS (*KLOMBOTHRIPS MYOPORI*) INFESTATION ON NATIVE *MYOPORUM* IN HAWAII

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Myoporum thrips, *Klambothrips myopori,* is a recently established invasive species that infests the native naio, *Myoporum sandwicensis*, in Hawaii. Feeding damage include leaf distortion and gall-like symptoms. Severe infestation cause branch die back and could eventually result in tree death. Thrips infestations are currently restricted to the Big Island, but it is likely to spread throughout the Hawaiian Islands. Project objectives include assessing current distribution, rate of spread and impacts of this invasive species on naio populations. We present an outline of the project, monitoring sites, as well a description of current survey and monitoring protocols. Project results will help resources managers take important and timely management actions in the event that this species become established on other main Hawaiian Islands.

ABILITY AND REPRODUCTIVE CHARACTERISTICS OF *HOMALODISCA VITRIPENNIS* (GERMAR) (HEMIPTERA: CICADELLIDAE) FROM GEOGRAPHICALLY SEPARATED POPULATIONS IN CALIFORNIA

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The glassy-winged sharpshooter (GWSS), *Homalodisca vitripennis* (Germar), is native to the southeastern United States and northeastern Mexico. It was detected in southern California in the late 1980s and in the San Joaquin Valley in 1999, where it transmits the bacterium *Xylella fastidiosa* to grapevines and other crops. The transmission efficiency of *X. fastidiosa* to grapevines and the reproductive success of hybrid and pure line GWSS from two allopatric populations in California (Riverside (RIV) and Bakersfield (BAK)) were evaluated under identical controlled conditions. To test the effects of GWSS origin (RIV versus BAK), gender, and age on transmission, insects were given a 96h acquisition access period on infected grapevines and a 72h inoculation access period on healthy grapevines. At conclusion of the test, ~26% of test plants were infected, with no effect of GWSS origin, gender, or age on transmission, confirming that these factors do not affect transmission. Comparison of reproductive success based on origin found that the preoviposition period in both female generations was significantly shorter for RIV (F_0 = 28.2 days and F_1 = 62.3 days) than BAK females (F_0 = 46.1 days and F_1 = 170.4 days). There were no significant differences in fecundity and longevity among the F_0 and F_1 mating pair treatments. There was a gradual decrease in the number of viable eggs deposited by GWSS females, suggesting that females exhausted sperm reserves and that re-mating may be necessary to produce viable progeny. From a management perspective, delayed reproductive maturity and polyandry are weak links in GWSS's biology that may be exploited through mating disruption or insect sterilization strategies to reduce population growth and augment pressure by natural enemies.

INVASIVE ANTS IN HAWAII AND THE PACIFIC: AN OVERVIEW OF CURRENT TRENDS

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It is currently believed that all ants in Hawaii have been introduced to the islands through human activities, mainly over the past 100 years. Today, nearly 60 ant species have become established in Hawaii, and some of these are major pests in urban areas. Management of ant pests often requires an understanding of the identity and biology of the target species, which becomes more challenging as new species continue to arrive. I will provide an overview of problems caused by invasive ants, patterns of ant species arrival in Hawaii, status of some of the more damaging species, recent additions to the state's ant fauna, and new species to watch out for.

THE ROLE OF INVASIVE INSECTS IN CONSERVING NATIVE HAWAIIAN INSECT BIODIVERSITY: WHAT IS KNOWN AND WHAT IS NEEDED

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Since the era of major habitat alteration ended in Hawaii, invasive insect species have become one of the most important threats to native insect persistence. I will discuss what is known about the effects of the better studied invasive insects, such as social Hymenoptera, as well as emerging patterns of invasive and native insect biodiversity across different habitats. I will also touch on the types of information we still need to know to more successfully conserve native insect biodiversity.

INDUSTRY RESPONSE AND IMPLEMENTATION TO COFFEE BERRY BORER IN HAWAII

Dan Kuhn

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Hawaii-grown coffee is an industry of over 800 coffee farmers with an estimated value of over 27 million dollars annually. The industry is represented by five organizations including a state-wide organization and several smaller regional organizations. The discovery of coffee berry borer in Kona resulted in an immediate need to organize the industry to be able to disseminate information about the pest, develop comprehensive plans to delimit, control and manage the pest and establish a framework with state officials and the research community. Some of the activities that were undertaken to facilitate communication were initiation of meeting with the growers, the establishment of a coffee berry borer task force made up of growers, processors, Hawaii department of agriculture and the various state and federal research entities. Within the task force an executive committee, scientific advisory panel and legislative outreach subcommittees were formed. Activities performed on behalf of the task force included, a quarantine to prevent the spread of CBB, field days to inform growers on CBB, a bill in the legislature requesting funds to deal with the CBB problem and a pamphlet on CBB for tourists.
While coffee berry borer represents a concern for the industry, close collaboration between the industry, governments and research entities will hopefully establish measure that will help mitigate the pest.

COFFEE BERRY BORER IN HAWAII

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The Coffee Berry Borer (CBB), *Hypothenemus hampei* (Ferrari), is a major pest in coffee-growing regions throughout the world. It bores through the berry and attacks the bean, rendering

it unsuitable for market. CBB was first detected in Hawaii in late August 2010 in the Kona area on Hawaii Island, where world-premier coffee is grown. The initial identification was made by Hawaii systematists, and the final determination was made by the USDA Systematic Entomology Laboratory. Since this was a pest of known economic importance, the National Plant Diagnostic Network Standard Operating Procedure for: APHIS-PPQ Pest of Concern was utilized to enhance rapid identification and notification. Following a delimiting survey, an interim quarantine was instituted on December 2, 2010 for Hawaii Island. In a collaborative effort, staff from the Hawaii Department of Agriculture and other government agencies are working together to develop methods to control CBB and to assist farmers in mitigating the effects that CBB may have on coffee crops.

DEVELOPING AN IPM PROGRAM TO MANAGE PEPPER PLANT PESTS

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Integrated pest management in fresh market bell peppers has not been a priority for growers in California until recently. In 2009, the CA Pepper Commission voted to move toward IPM as a primary control strategy. This provided an opportunity for us to increase our efforts to develop economically viable IPM strategies. Initial trials were performed to identify key pest insects and key biocontrol agents. A series of insecticides were tested to determine which were effective in controlling pepper pests. The better performing compounds were utilized in a comprehensive IPM program. The objective of the IPM program was to develop an economically viable approach for the commercial production of peppers that complies with the Food Quality Protection Act, maximizes worker safety, and reduces resistance development. A prospective IPM program was developed using low toxicity materials that was compared to a 'chemical standard' approach and a control in a randomized block field trial. Upon completion of the trials, the fruit were harvested and analyzed for insect damage. These data were then subjected to a simple, partial budget economic analysis. The results and the continuing development of an IPM program are discussed.

ESTIMATING AND OPTIMIZING SENSITIVITY OF DETECTION TRAPPING SYSTEMS FOR TEPHRITID FRUIT FLIES

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The sensitivity of a detection trapping system can be expressed as the relation between the likelihood of capturing one or more insects and the size of the population within the area being trapped. In practice, understanding detection sensitivity requires knowledge of (among other things) the probability of capturing an insect at various distances from a trap. For this presentation, distance/capture functions are derived from mark-recapture studies, primarily focusing on data from releases of sterile Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) into operational detection trapping systems in California and Florida. The functions are used to

compute detection probabilities directly and to develop Monte Carlo simulations of incipient populations within a detection trapping grid. The simulations assume that populations of varying size each start at a point source but grow numerically and spread until fly is captured in a trap. Several strategies are considered for enhancing sensitivity of the systems within a fixed set of resource. Most notably, moving traps on a scheduled basis among a number of trap locations – a common practice in California and Florida – did not help detect populations at a very small size but was important in ensuring that populations did not grow to an unmanageably large size before at least one fly was captured. Overall, results of simulations indicate that the size of a population at detection can vary across a fairly broad range of sizes depending on factors that are largely matters of chance. Expectations of population size at detection, whether arranged as a single localized population or broken into multiple sub-populations, will be presented given various trapping scenarios. These results will be discussed in relation to various proposed explanations for the observed patterns of fruit fly detection in California.

ATTRACTANTS AND BAITS FOR PESTIFEROUS AND SOCIAL WASPS.

Peter J. Landolt

Chemical attractants and food-type baits for social wasps are useful in traps for detection programs and have potential for suppression of wasp numbers in defined areas. Research has produced a set of chemical lures that are attractive to many temperate species of Vespidae and some Polistes. Several successes in this area are detailed. Chemical lures are not available or are not proven for additional species of pestiferous and invasive wasps, including many subtropical and tropical species. Opportunities for further development of lures and trapping systems include sex and aggregation pheromones, and feeding attractants.

INTERACTION OF ACETIC ACID AND ETHANOL AS ATTRACTANTS FOR THE SPOTTED WINGED DROSOPHILA, *DROSOPHILA SUZUKII*, (DIPTERA: DROSOPHILIDAE).

Peter J. Landolt[1], Todd Adams[2] and Helmuth Rogg[2].

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Recommendations for monitoring spotted winged Drosophila (SWD) in the western U.S. and Canada calls for the use of vinegar or wine as a bait for traps, which may be due largely to the evaporation of acetic acid and ethanol from those traps. Numbers of both male and female SWD flies in traps baited with a mixture of acetic acid and ethanol were significantly greater than numbers in traps baited with vinegar alone or wine alone. Similarly, traps baited with the combination of vinegar and ethanol captured many more SWD flies than traps with acetic acid, or traps with wine. These results indicate a synergy of the two chemicals, and of the two materials, in attracting SWD. A comparison of acetic acid with ethanol versus vinegar with wine, showed also stronger attraction of the vinegar/wine solution, indicating attractiveness of chemicals in addition to acetic acid and ethanol.

AEDES JAPONICUS JAPONICUS: A NEW MOSQUITO IN HAWAIIAN BIRD HABITAT AND ITS POTENTIAL AS A VECTOR OF AVIAN MALARIA

Dennis A. LaPointe

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Mosquito-borne disease, avian malaria and avian pox, are key limiting factors in the extinction and population decline of Hawaiian forest birds. In 2002, the mosquito *Aedes japonicus japonicus* was first detected on the Island of Hawaii and by 2005 had become established in natural areas. To assess the spread and vector potential of *Ae. j. japonicus* in forests inhabited by native Hawaiian birds, we surveyed larval mosquito habitat and trapped adult mosquitoes in a mid-elevation (1,100 m above sea level) rainforest adjacent to Hawaii Volcanoes National Park. Mosquitoes were dissected for parity and evidence of malarial infection. We also conducted susceptibility trials by exposing *Plasmodium relictum*-infected Pekin ducklings to local populations of *Ae. j. japonicus* and a competent mosquito vector, *Culex quinquefasciatus*. We found that *Ae. j. japonicus* were common in our study site and larvae were found co-inhabiting tree fern cavities with *Cx. quinquefasciatus*. While the prevalence of infected, field-collected *Cx. quinquefasciatus* ranged from 39-55%, no field-collected *Ae. j. japonicus* (N = 218) were found harboring oocysts or sporozoites. In paired laboratory trials, 23-100% of exposed *Cx. quinquefasciatus* were susceptible to and supported complete development of *P. relictum*. However, no signs of *P. relictum* development were seen in laboratory-exposed *Ae. j. japonicus* (N = 120). It appears that while *Ae. j. japonicus* has successfully established year-round populations in Hawaiian forest bird habitat on the Island of Hawaii, it is not a competent vector of *P. relictum* and may have only a minor role in disease transmission as a mechanical vector of avian pox virus.

DEVELOPMENT OF A SEQUENTIAL BINOMIAL SAMPLING PLAN FOR *OLIGONYCHUS PERSEAE* (ACARI: TETRANYCHIDAE) ON AVOCADO

Jesus R. Lara[1] and Mark S. Hoddle[1]

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A sequential binomial sampling plan was developed for persea mite (*Oligonychus perseae*) infesting 'Hass' avocados. Mite count data for 30,656 leaves from 9 commercial avocado orchards in California was used to model the relationship between the mean number of persea mites per leaf and the proportion of leaves infested with ≥1 mite. Leaves are collected randomly and examined sequentially to calculate the proportion of infested leaves. A recommendation to treat for mite control is made when a critical proportion (0.978) of infested leaves, which corresponds to a threshold of 100 mites per leaf, is exceeded. A total of 33,000 re-sampling computer generated simulations of 33 additional data sets (4,686 leaves) were used to validate the practical application of the sampling plan based on the Operating Characteristic (OC) and Average Sample Number (ASN) curves.

INSECTICIDE RESISTANCE IN THE WESTERN TARNISHED PLANT BUG

Laura Corley Lavine[1], Keriann Bennett[1], David Hawthorne[2], and Douglas Walsh[3]

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A major problem for integrated pest management strategies is the widespread increase of insecticide resistance. Species of *Lygus* in North America are estimated to cause millions of dollars in yield losses in cotton, corn, peaches, strawberries, raspberries, apples, alfalfa, and alfalfa seed. Insecticide resistance in plant bugs is largely known from the tarnished plant bug, *Lygus lineolaris* in cotton and fruit crops. Populations of these insects have been reported to have resistance to different classes of insecticides such as carbamates, organophosphates and pyrethroids. Frequent exposure to different classes of pesticides no doubt contribute significantly to multiple pesticide resistance in *Lygus.* Mechanisms for insecticide resistance include behavioral adaptations, genetic mutation, and increases in the expression of cellular detoxification pathways. Interestingly, insects that are resistant to one insecticide, under strong selection, generally develop cross-resistance to other classes of insecticides such as that seen in *L. lineolaris.* Our objective was to determine insecticide resistance in the western tarnished plant bug, *L. hesperus* from populations known to be subjected to multiple pesticide chemistries over many different years. We collected western tarnished plant bug adults from alfalfa fields in central Washington state and tested for insecticide resistance against seven commonly used pesticides. We also conducted pharmacological inhibition studies to determine possible physiological and genetic mechanisms of resistance in the western tarnished plant bug. Not only do western tarnished plant bugs exhibit resistance to commonly used pesticides in alfalfa, we also suggest a possible physiological mechanism underlying cross resistance in our study.

WHAT'S NEW FROM FMC

Leland W. Learned and Robert Hooten

FMC Corporation, 1735 Market Street, Philadelphia, PA 19103

FMC will be introducing two new insecticides in 2011. Athena™ is a new insecticide / miticide whose primary markets will be tree crops, vegetables, strawberries and cotton. Stallion™ is a new insecticide being introduced into alfalfa, corn, wheat, cotton, sunflower, and citrus markets. Basic information on Athena and Stallion will be presented here and, more detailed information will be presented in individual presentations for each product. Information will also be presented on label updates for Hero®, Beleaf™, and Brigade® WSB.

ATHENA™ - A NEW INSECTICIDE / MITICIDE FROM FMC CORPORATION

Leland W. Learned, Rusty Mitchell, Curtis Sandberg, Robert Hooten, and Robert Leifker

FMC Corporation, 1735 Market Street, Philadelphia, PA

Athena™ is a new insecticide – miticide from FMC Corporation that received EPA Section 3 Registration in late 2010 for use on tree nuts, vegetables, cotton, and strawberries. California registration is pending. Athena's proprietary formulation is low odor and low VOC. The unique formulation penetrates tough mature leaves and allows flexibility in application timing. The combination of two modes of action (IRAC Classes 3 & 6) provides excellent control of important economical pests. This presentation provides data to demonstrate the effectiveness of Athena in controlling *Amyelois transitella* (Walker) (navel orangeworm), *Anarsia lineatella* Zeller (peach twig borer), and *Tetranychus spp.* (web-spinning spider mites) in almonds and, *Lygus spp.* (plant bugs) and web-spinning spider mites in strawberries and cotton.

DISTRIBUTION AND ABUNDANCE OF ENDEMIC DROSOPHILIDAE IN THE HAWAIIAN FOREST AND AGRICULTURAL ENVIRONMENTS

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The distribution, abundance and biodiversity of endemic Hawaiian Drosophilidae on the islands of Hawaii and Maui are reported, based on maintaining traps in endemic forest, nonnative forest and farmland, in a study of attraction of nontarget insects to fruit fly (Tephritidae) female food attractants and male lures, and on reviewing existing literature and examining museum specimens. Of the 291 species expected to occur around the sampled areas, 121 were collected. Numerically dominant groups were the *Antopocerus*, spoon tarsus, split tarsus, *haleakalae*, *Elmomyza*, and *Engiscaptomyza*, and 91% of the captured specimens belonged to 24 common species. The majority of the captured individuals with known hosts were breeders on *Cheirodendron* leaves or fungus at the larval stage. Endemic species were still collected, in smaller numbers, in the strawberry guava belt, tropical ash and pine and *Eucalyptus* plantation forest, as distant as almost 500 m from native forest. A diversity (24 species) of endemic drosophilids were collected in fruit and coffee orchards and their adjacent nonnative forest, as far as 10 Km from endemic habitats. Recommendations to reduce the possible impact of fruit fly management practices on endemic drosophilids are discussed. The introduced *Drosophila suzukii* was also commonly collected at every site during the survey.

DOW AGROSCIENCES URBAN PEST MANAGEMENT BUSINESS NEW PRODUCT UPDATE

M. Lees[1]

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The Urban Pest Management business within Dow AgroSciences encompasses all of the pest management needs in and around residential and commercial structures and landscape and ornamental plant production. This wide-ranging business strives to protect home and business owners from pests that may cause financial as well as health related damage. This presentation will provide an update on recent developments in the Urban Pest product portfolio.

DEVELOPMENT AND VALIDATION OF RECRUIT HD TERMITE BAIT FOR CONTROL OF SUBTERRANEAN TERMITES IN THE WESTERN U.S.

M. Lees[1], J. DeMark[2], J. Eger[3], E. Thoms[4], M. Fisher[5], M. Melichar[6], R. Hamm[6], and J. McKern[7]

[1]Dow AgroSciences, Granite Bay, CA, [2]Dow AgroSciences, Fayetteville, AR, [3]Dow AgroSciences, Tampa, FL, [4]Dow AgroSciences, Gainesville, FL, [5]Dow AgroSciences, Dallas, TX, [6]Dow AgroSciences, Indianapolis, IN, [7]Dow AgroSciences, Fresno, CA, [8]Dow AgroSciences, Christiansburg, VA

The use of baiting for control of subterranean termites (Isoptera: Rhinotermitidae) has changed and improved over many years. The most successful commercial bait product is the Sentricon® Termite Colony Elimination System introduced in the early 1990s and currently marketed by Dow AgroSciences. A new baiting concept utilizing Recruit™ HD durable bait has been developed and tested throughout the United and is now registered for use in all states. The introduction of this new tool may dramatically change the way in which baits are utilized. Prior to introduction of Recruit HD, monitoring stations were inspected monthly or quarterly for termite presence or activity. At this point, a cellulose bait device containing noviflumuron, a benzoylurea chitin synthesis inhibitor, was placed into the station. Termite workers fed and transferred the bait. The growth regulator prevented successful molting resulting in gradual collapse and elimination of the colony. With Recruit HD, a highly durable bait device containing the same growth regulator is placed in every station at installation. When termites hit a station, they begin feeding on the bait immediately and the process of elimination begins. Because every station is already baited, inspection intervals can be extended up to annually. Reduction in service intervals reduces the labor costs associated with baiting and makes this method of control more competitive with traditional liquid termiticide applications. Laboratory and field research over the past 6 years has demonstrated that this new bait will eliminate termite colonies in and around homes and provide protection against new infestations. Over 100 structures across the U.S. were involved in research trials with this new concept. Summaries of these sites as well as laboratory findings of efficacy, palatability and durability will be presented. Current data support this concept as a revolutionary new method of termite control with reduced use of pesticide active ingredient compared to traditional liquid termiticide treatments.

PICKLEWORM IN HAWAII: PROSPECTS FOR MANAGEMENT

Rosalie Leiner and Helen Spafford

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The pickleworm, *Diaphania nitidalis* (Lepidoptera: Crambidae), is a relatively new pest in Hawaiian cucurbit production. Growers rely heavily on insecticide sprays for pickleworm management but this is an unsustainable practice due to the increased likelihood that insecticide resistance will evolve and the sprays disrupt the existing biological control for other cucurbit pests, *Aphis gossypii* and *Liriomyza* spp. With the rise of organic crop production and the threat of the loss of insecticidal control, a new approach to pickleworm management in Hawai'i is

crucial. The overall aim of this project is to investigate the oviposition preference of the adult pickleworm moths as related to a potential push-pull crop protection system for pickleworm management. Early researchers observed the potential of squash as a trap crop for pickleworm management on muskmelon and cucumbers, however this practice has not been thoroughly investigated. An in depth knowledge of the oviposition preference of pickleworm is the first step in determining which plants could function as a trap crop (pull) as well as finding possible intercrops that could serve an oviposition repellant (push). The use of a push-pull crop protection strategy has been successfully used to manage another crambid moth on maize. This project will be the start of creating a push-pull cucurbit protection strategy for pickleworm management in Hawai'i.

IDENTIFICATION AND FIELD BIOASSAYS OF THE SEX PHEROMONE OF *SYNANTHEDON VESPIFORMIS* (LEPIDOPTERA: SESIIDAE)

Anat Levi-Zada[1], Shaul Ben-Yehuda[2], Ezra Dunkelblum[1], Galina Gindin[1], Daniela Fefer[1], Alex Protasov[1], Tatiana Kuznetsowa[1], Shulamit Manulis-Sasson[1] and Zvi Mendel[1]
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The yellow-legged clearwing (YLC) *Synanthedon vespiformis* (Lepidoptera: Sesiidae) occurs in the Mediterranean and central Europe. It is polyphagous, boring into the woody parts of broadleaf species including forest trees as well as various Rosaceae species. YLC has been reported as an economically important pest causing severe injury to stone fruits plantations. A frequent association between YLC and tumors caused by the crown gall disease induced by *Agrobacterium tumefaciens* in stone fruits has been reported.
About twenty sex pheromones of sesiid species have been identified. Also, useful baits for other sesiids were revealed in field screening using 2,13 and 3,13-octadecadienyl alcohols, acetates and aldehydes. Thus, an efficient bait was determined for YLC as well. The objectives of the present study were as follow: (i) to identify the natural composition of the sex pheromone of YLC, (ii) to develop an efficient lure for monitoring of the pest, and (iii) to study the feasibility of mating disruption with commercial pheromone dispensers.
The natural sex pheromone of YLC is a blend of *E*3,*Z*13- and *Z*3,*Z*13- octadecadienyl acetates, at 8:2 ratio. The pheromone was extracted from the glands of females reared on artificial diet. Funnel (IPS) traps baited with rubber septa impregnated with this pheromone blend captured efficiently the males for 4-5 weeks. Suspension of ShinEtsu ropes containing a 2:1 blend of *E*3,*Z*13-18:Ac and *Z*3,*Z*13-18:Ac, 6.87mg/ha/h, resulted in shut-down of traps, indicating that mating disruption is feasible.

NATIVE HAWAIIAN CARABID BEETLES: THEIR RELATIVE PERSISTENCE AND UTILITY FOR CONSERVATION MANAGEMENT

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Hawaii's native carabid beetles have evolved predominantly from three colonists, resulting in a dominant insect predator guild of over 400 species. Ecological relationships of the various species underlie their relative persistence in the face of developmental pressures, with mesic koa species especially at risk. Interpreting phylogenetic relationships of closely related species in light of their geographic distributions elucidates the barriers facilitating allopatric speciation. On the older, more highly eroded islands of Oahu and Molokai, distinct areas of endemism populated with particular endemic species can be identified. Conversely, the carabid fauna of the younger island of Maui illustrates the confounding and confusing effects of rampant diversity, as vicariant barriers between different sets of sister species are not geographically coordinate. To maximize conservation of biodiversity on the older islands we can focus on conserving the various, distinct areas of endemism. However to similarly conserve biodiversity on Maui, we must conserve larger areas that presently support actively evolving populations and species.

MAKING THE INVISIBLE, VISIBLE: HAVING STUDENTS MAKE AND ANALYZE MOVIES IN A CLASS

Catherine Loudon

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Scientists use a variety of different imaging and videography methods as part of their research methodology or data collection and analysis. Students rarely have the opportunity to be exposed to these types of methods as part of their undergraduate education. In order to bridge this gap, I have developed a class in Image Processing and Analysis in Biological Research, as well as requiring students to make movies in an Entomology class. While there are a number of practical hurdles in involving students in such projects (access to cameras, computers, software), students are generally enthusiastic about making and analyzing movies, and their interest is piqued as they become more aware of the limitations of their own sensory systems. In my Image Processing and Analysis class, we pair different techniques with scientific research questions that can be addressed by such techniques. For example, we learn flow visualization techniques to quantify movement of air or water in natural environments. The students use these flow visualization techniques to explore chemical communication in insects; the students record the movements of soap bubbles (in a park on campus) to analyze the air movements and are able to experience firsthand the difficulties of following a "pheromone plume" in shifting wind conditions. High-speed videography was used to analyze insect gaits and sound production in crickets, time lapse photography was used to quantify evaporation of water from different surface shapes, and thermal cameras were used to non-invasively measure insect temperatures and identify hot plants. I have found this approach to be very successful in teaching students about exciting research in insect behavior, biomechanics, and sensory ecology, as well as some of the fun of doing science.

WIDESPREAD NATIVE OR CRYPTIC INVADER? PHYLOGEOGRAPHY OF THE PACIFIC ANT, *TETRAMORIUM PACIFICUM* MAYR

Andrea Lucky and Robert R. Dunn

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We investigate the evolutionary dynamics of an ant species widespread among Pacific islands, *Tetramorium pacificum* Mayr. The species is known to be invasive in other parts of the world, however, it is not known whether its distribution throughout the Pacific is also a result of recent invasion assisted by humans, or a native range of an adaptable and highly dispersive species. Using molecular markers, including mtDNA and microsatellite markers, we assess the relationships among populations from islands of the southwest Pacific, infer boundaries of the native range of this species, and test the true origins of nominally 'native' and 'non-native' populations. The degree of intraspecific divergence within and among populations will distinguish whether each species is a widespread native, a cryptic complex, or is a recent introduction. Analysis of node ages in the resulting population map allow us to test hypotheses about the mode of dispersal to remote islands by *T. pacificum*, and clarify the role of human transport, such as whether long-distance dispersal has been caused by recent shipping, or ancient human migration. This information is critical for conservation strategies that rely on designations such as 'native' or 'invasive' to protect or restore vulnerable communities.

MANAGEMENT OF CHILLITHRIPS

Scott W. Ludwig

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Chillithrips, *Scirtothripsdorsalis* (Hood), is an important pest of crops in tropical and subtropical regions. An established population of this pest was first detected in the United States on landscape roses in Florida in 2005. Since that time chillithrips have been detected in Georgia, New York, Alabama, Louisiana, Texas, and Hawaii. Retail plants and liners appear to be the main method of movement for this pest. There are a number of products that are effective in managing chillithripson greenhouse and nursery crops. There are fewer effective insecticides available for use on landscapeplants.

TARGETING INVASIVE SPECIES WITH SPLAT ATTRACT & KILL

Agenor Mafra-Neto[1], Lyndsie Stoltman[1], Carmem Bernardi[1], Diego Zeni[1], Lisiane Perez Silva[1], Marcos Botton[2], Odimar Zanardi[2], Leandro Mafra[3], Rafael Borges[3] and Roger Vargas[4]

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A successful attract & kill formulation can have a greater impact on a pest population than a traditional mating disruption formulation by removing the target insect from the mating pool. These formulations require extensive research in order to determine the appropriate density of point sources in the field as well as the correct proportion of attractant and insecticide needed to achieve contact between the insect and the point source. Still, the benefits of a successful attract & kill formulation are great, including a reduction in the total amount of semiochemical needed to achieve control, as well as improved, more reliable results. In the US, particularly in the Pacific coast region, we have become acutely aware of the difficulty in controlling invasive pests that have established themselves in our urban, agricultural and forest ecosystems. The critical success of eradication programs will depend on the use of swift, targeted measures designed to eliminate invasive populations without disturbing our native areas. Semiochemicals are ideal for these types of programs, which is why we have been working toward the development of numerous attract & kill formulations incorporated into our patented SPLAT (Specialized Pheromone & Lure Application Technology) matrix. Some of our greatest successes have resulted from attract & kill formulations, including SPLAT PBW A&K, designed to synergize the attractiveness of the pheromone with insecticides to increase mortality . Here we will present an overview of attract & kill formulations developed for palm beetles *Rhyncophorus ferrugineus, R. palmarum* and *Oryctes rhinoceros,* Lepidopterans *Tuta absoluta* and *Epiphyas postvittana,* and invasive fruit fly pests.

CONSERVATION STATUS OF THE HAWAIIAN PICTURE-WING *Drosophila*

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The Hawaiian picture-wing *Drosophila* are one of the most famous insect radiations in the islands, as examples of adaptive and sexual selection and as the largest and most colorful members of Drosophilidae in the world. Nearly all of the 117 species are oligophagous on rotting bark of one or a few native tree genera. Due to increasing habitat loss and the effects of invasive plants, ungulates, and other insects, many species have significantly declined since major collecting began 50 years ago. We evaluated all species in the picture-wing clade using standardized IUCN Red List criteria and GIS maps of recent and historic collection localities. An extremely high proportion are at high risk of extinction, particularly on Oahu and Hawaii where over half of the species are critically endangered due to dramatic range contractions. Because many species co-occur, a considerable number of species can be protected with relatively little effort by concentrating on high-diversity sites. However, many of these are not currently protected because they are not focal areas for rare plants, which have been the main drivers of conservation decisions. Without consideration of invertebrate diversity in conservation planning, the largest component of native biodiversity is being ignored.

EFFECTS OF COVER CROPS ON PARASITISM OF *HELICOVERPA ZEA* AND OCCURRENCE OF *ORIUS* SPP. IN CORN INTERCROPPING SYSTEMS

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As an alternative strategy to manage the corn earworm, *Helicoverpa zea* (Bodie), cover crops were assessed for effect on *H. zea* natural enemies in corn. Three cover crops, buckwheat; *Fagopyrum esculentum*, cowpea; *Vigna unguiculata* and sunn hemp; *Crotolaria juncea* were intercropped with corn, to study rates of *H. zea* egg parasitism and occurrence of a predator, *Orius* spp. Initial assessment on sunn hemp and cowpea showed that eggs of Lycaenidae butterflies laid on buds and flowers were parasitized by *Trichogramma*. On an average, 16.6% and 62.0% of Lycaenidae eggs were found parasitized on sunn hemp and cowpea inflorescences, respectively. To determine the percentage parasitization in adjacent corn, *H. zea* eggs found in the silks from each treatment habitat were capsulated in a gel cap and observed for emergence of either larvae or parasitoid. The percentage of parasitization of *H. zea* eggs on corn by *Trichogramma* were found to be highest in cowpea habitat 34.6%, followed by sunnhemp 30.8%, and lowest in Buckwheat 17.7%, and habitat manipulation did not show significant effect on *H. zea* egg parasitization rates. However, a separate analysis on proportion of *Trichogramma* - larvae emergence showed a significant effect of treatment habitats on emergence rates. Also, occurrences of *Orius* spp. in corn silks were found to be significantly higher in sunn hemp habitat compared to corn monoculture. No significant effect of cover crops was found on sweet corn yield in different habitats. In conclusion, cover crops may provide food (nectar, pollen and prey) and alternative host (Lycaenidae eggs) for parasitoids and predators, which then move into corn plantings to devour *H. zea* eggs.

QUANTIFYING AND ANALYZING THE MOSQUITO DANCE IN MATING SWARMS

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Mating and swarming behaviors of mosquitoes in nature are rarely described or studied, and even more rarely quantified. The principal reason this stage of mosquito life history remains unexplored is that direct observation and quantification of mating in swarms is very difficult due to the small size of mosquitoes, their relatively fast rate of movement and their habit of aggregating under conditions of low light. Despite our lack of knowledge in this area, determinants of male mating success in medically important species are of major interest from a fundamental and applied perspective. We estimate three-dimensional positions and velocities of individual mosquitoes through space and time from stereoscopic video footage obtained in the

field in Mali by employing advanced image processing and probabilistic estimation techniques in a semi-automated computer tracking system. We verify the accuracy of our tracking system by multiple measures. We have used this system to quantify and analyze instances of coupling in *An. gambiae* swarms. These measurements reveal that female *An. gambiae* spend much more time in a swarm composed almost entirely of males than previously thought: more than six seconds in one instance. We will describe ongoing studies in which we are quantifying the differences in the flight patterns of males and females within the mating swarm and studying male flight patterns for determinants of male mating success. These data and the increasingly automated capacity in which we generate them promise to greatly extend our fundamental understanding of *An. gambiae* mating biology and have implications for any release-based approach to its control as a malaria vector.

FACTORS IN ACHIEVING SUSTAINABILITY AND MEASURING THE IMPACT OF TERMITE PREVENTION CURRICULUM IN PUBLIC SCHOOLS IN HAWAII.

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"Educate to Eradicate" is a K-12 curriculum project using termite biology and control as the basis for science education that has been implemented in over 200 Hawaii public school classrooms; and is coupled with community outreach efforts. The present study was initiated to (1) identify factors that influence the adoption and continuation of our pest management curricula in public school classrooms, and (2) evaluate the efficacy of these community education efforts. Logistic regression analysis was applied to survey data from 62 partner teachers. The probability of a teacher continuing into the next year was modeled on the basis of grade level, science background, years of teaching, perceptions of project content/pedagogy and school socioeconomic status. Grade level was a significant predictor of continuation. Elementary teachers had a 67.9% probability of repeating, while this dropped to 20.4% probability with Intermediate and High School teachers. Secondly, we evaluated gains in student learning through pre-test and post-test comparisons. Mean student score increases ranged from 24-29%. Lastly, efficacy of the program in promoting termite suppression was measured through student engagement in extension activities and changes in knowledge of termite prevention. Student prevention knowledge increased between 24%-33% after participation in the Educate to Eradicate curriculum. The goal of this program is a self-sustaining curriculum that will require limited institutional inputs, increase science literacy in Hawaii schools, and help to protect current and future homeowners from termite damages.

A DIAMONDBACK MOTH INSECTICIDE RESISTANCE MANAGEMENT PROGRAM FOR CONTINUOUS CRUCIFER PRODUCTION

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In Hawaii, crucifers are planted and harvested every week of the year to satisfy local fresh market needs. Due to the close proximity of family operated farms and the practice of growing crops in adjacent, sequential plots, the diamondback moth, *Plutella xylostella* (Linnaeus), is always present. It is usually a significant pest from March through October. Other lepidopterous pests include the–imported cabbage webworm, imported cabbageworm, beet armyworm, and cabbage looper. Growers experience yield losses of 20 to 40% and complete losses occur without effective pesticide treatments. Insecticides sprays are applied weekly when DBM populations surpass 0.5 to 1 larva per plant. Growers' continual reliance on sequential insecticides sprays of the same IRAC Mode of Action (MOA) groups have resulted in resistance to insecticide products with MOA groups 1, 2, 3, 5, 11, 15, and 22.

As a result, insecticide resistance management program was developed that relies on population monitoring for insecticide susceptibility and month-long regional product-use windows. Dose-mortality assays are performed for each newly introduced–effective new MoA insecticide product. The lowest complete mortality concentration calculated by probit analysis is used as the single, discriminating dose for the leaf dip assays. Populations are monitored in spring and fall seasons from the three major crucifer production areas on Oahu, Maui and Hawaii Islands. The seasonal assay results are used to determine MoA insecticide spray rotations that reduce rapid selection of resistance in populations and to mitigate resistance where resistance genes confer a moderate fitness cost in populations. The results of the seasonal assays are presented at grower meetings by Cooperative Extension advisors and decisions on the rotation schedule are made be the entire group.

WHEN "LEAVING A LIGHT ON FOR YOU" IS NOT WELCOMING: PROTECTION OF YOUNG CACAO ORCHARDS FROM CHINESE ROSE BEETLE DEFOLIATION

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The Chinese rose beetle, *Adoretus sinicus* (Burmeister), is a scarab presently found in China, Taiwan, Hong Kong, Indonesia, Kampuchea, Laos, Singapore, Thailand, Vietnam, the Marianas Islands, the Caroline Islands and the Hawaiian Islands. In the Hawaiian Islands, it was first reported on Oahu in 1891 and, by 1898, was established on all major Hawaiian Islands. The adult stage is a polyphagous herbivore whose aggregate nighttime feeding can stunt or even kill host plants. Among affected commercial crops in Hawaii, the Chinese rose beetle is one of the worst pests of young cacao (*Theobroma cacao* L.) trees, often causing complete defoliation. One promising, environmentally friendly, control method takes advantage of the avoidance of light by adult Chinese rose beetles when they select the host plant on which they will feed at night. Illumination of plants at dusk has the potential to discourage feeding on the illuminated plant. We tested the effectiveness of nighttime illumination, using LED-based solar lighting, on control of beetle populations in two comparable cacao orchards in Pepeekeo, HI. Numbers of beetles on each cacao plant were counted in each orchard for eight successive nights, with nighttime illumination initiated on night 5 in one of the orchards (Treatment) while no lighting was provided in the 2nd orchard (Control). The trial was repeated with control and treatment orchards switched. Beetle numbers were reduced over 96% (Orchard 1) and over 97% (Orchard 2) of pre-illumination levels after 4 nights of illumination. Total beetle numbers in Orchard 1 subsequently dropped as low as zero with extended (5 weeks) nighttime illumination.

GOWAN COMPANY INSECT MANAGEMENT UPDATE

Gary Melchior[1]

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This presentation will provide an update on recent developments in the insect management product portfolio for the crops business of Gowan Company.

COFFEE BERRY BORER: SCRAMBLING FOR ANSWERS IN HAWAII'S UNIQUE AGRO-ECOSYSTEMS.

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Since coffee berry borer was first detected in Hawaii several months ago, researchers have been scrambling to find ways to help growers and processors mitigate damage and economic loss in one of the state's major agricultural commodities. As CBB is a well-known pest from coffee-growing areas around the world, the advice from experienced scientists in other regions was "*don't re-invent the wheel*." However, the existing published literature is far from clear on several major issues regarding CBB biology, including methods of trapping and the existence of alternate host plants. Also, from both ecological and an economic perspectives, Hawaii's coffee industry is unique; and the role that CBB (and its natural enemies) will play in our system may differ from that in other areas. Several preliminary lines of research have been opened to investigate CBB biology in the context of Kona agro-ecosystems; their possible contribution to integrated control is discussed.

SEX PHEROMONE OF *ACUTASPIS ALBOPICTA*, AN INVASIVE EXOTIC PEST ENTERING CALIFORNIA ON SHIPMENTS OF FRESH AVOCADOS FROM MEXICO

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Since the USDA relaxed its rules in February 2007 to allow the shipment of fresh avocados from Mexico into California year-round, routine inspection of these shipments has revealed that approximately one third of the inspected shipments are infested with armored scale species (Hemiptera: Diaspididae), including at least two previously undescribed species (Morse and Stouthamer, work in progress), and species with fairly broad host ranges. Given the high incidence of infestation of incoming avocado shipments, it is only a matter of time before new pest species become established in California. To have any chance of preventing the permanent and widespread establishment of at least some of these exotic species in California, it will be critically important to have a sensitive monitoring system for detection of small, localized

infestations that can be eradicated before they have a chance to spread. Probably the simplest and most effective method of detecting these insects would be through the use of traps baited with each insect's sex pheromone. Here, we present the identification of the sex pheromone of the first of these exotic pests, the scale *Acutaspis albopicta*. In preliminary bioassays, the pheromone proved to be highly attractive to male scales, confirming that pheromone-baited traps should be useful tools for detection and monitoring of this exotic pest.

DAMAGE ASSESSMENT AND IPM STRATEGIES FOR BLACK VINE WEEVIL IN CRANBERRIES AND BLUEBERRIES

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Short-term plant response to feeding by black vine weevil (*Otiorhynchus sulcatus*) larvae was assessed in cranberries and blueberries by inoculating potted plants with varying black vine weevil (BVW) egg or larval densities. In addition, entomopathogenic fungus *Metarhizium anisopliae* was evaluated and compared to the entomopathogenic nematode *Steinernema kraussei* for biological control of BVW. The standard pesticides imidacloprid and bifenthrin were also compared as potential damage mitigation options for BVW.

In cranberries, percent root damage was variety dependent, with no effect of feeding damage on root dry weight. Shoot growth was negatively affected at higher BVW egg densities and percent green leaf area decreased with increasing BVW egg density. Water use by the plants was reduced by increasing BVW densities. In blueberries, no short-term effect on shoot growth was observed. Root weight and berry weight decreased as BVW density increased, but no effect on total yield weight or berry number was observed.

Imidacloprid had no mitigating impact on BVW damage to blueberries, nor did it cause significant BVW mortality in cranberry fields. Bifenthrin caused increased BVW mortality in blueberry fields; however this mortality had no positive effect on blueberry root weight. In cranberries, *S. kraussei* had no impact on BVW mortality. The effect of *M. anisopliae* was inconsistent in both crops and dependent on variety, field site and method of application. It was, however, able to persist in cranberry fields and caused significant BVW mortality up to 12 months after application.

THE INVASION OF PACIFIC ISLANDS – SOME THOUGHTS ON INVASIVE SPECIES, INSULAR ECOSYSTEMS, AND HUMAN IMPACT IN THE WESTERN PACIFIC

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The history of the Western Pacific islands is replete with examples of invasions by alien species that have had a profound effect on the current environmental health of those islands. Many of these invasions have been caused or exacerbated by human activities including the initial settlement of the islands, regional and world wars, increasing international trade, and a general increase in regional and international travel. Guam, as a center for regional and international trade, travel and communication in the Western Pacific, has been especially impacted by invasive species including the brown tree snake, Asian cycad scale, and most recently the coconut rhinoceros beetle. The ongoing massive military buildup on Guam poses a threat to not only Guam, but by association to the more pristine islands and atolls of Palau, the Carolines, and the Marshall Islands. Biosecurity activities designed to prevent or mitigate the effects of invasive species in the region appear inadequate to prevent serious future incursions and further degradation of fragile Micronesian insular environments.

OUTCOMES OF ARSENATE AND PHOSPHATE EXPOSURE IN *CHIRONOMUS RIPARIUS*

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Though arsenic pollution is widespread worldwide, research evaluating the impacts it has on lower trophic levels is lacking. Agricultural runoff results in high inputs of phosphate into arsenic laden waterways where interactions occur in the soil, plants, and animals. Here, we evaluate how arsenate and phosphate interact to affect survival and reproduction in *Chironomus riparius*. Larvae were reared in beakers containing factorial combinations of 0, 10, 150, 400 and 1000 μg/l As and 0, 14, and 1400 μg/l PO_4. Survival and adult emergence were monitored daily starting five days after hatching and continued until all larvae had pupated or died. Reproductive changes were evaluated by counting the number of eggs per egg mass per female. Results from this study provide information regarding how these key pollutants affect population structure in *C. riparius*, which in turn may alter the flow of energy from aquatic to terrestrial systems.

EFFECTS OF POTATO VARIETY AND LOCALITY ON THE DENSITIES OF APHIDS THAT VECTOR POTATO LEAF ROLL VIRUS IN SOUTHERN IDAHO

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Potato leaf roll virus (PLRV) seriously constrains potato production in the Pacific Northwest (PNW) USA and worldwide. PLRV is transmitted by aphids in a persistent, circulative manner.

Green peach aphid (*Myzus persicae* Sulzer) is the most efficient vector but potato aphid (*Macrosiphum euphorbiae* Thomas) is also potentially important in many production areas. Withdrawal of some insecticides and failure of others to effectively control these vectors make it important to develop a sampling network to monitor their populations as a basis for developing improved vector and disease management. A survey was conducted in the potato growing areas of southern Idaho (near Aberdeen and Kimberly) in three predominant potato cultivars: Russet Burbank, Ranger Russet and Russet Norkotah. The objective was to compare aphid densities among these varieties in the field. Six untreated research plots (2 plots for each cultivar) from three different fields in each location were visited weekly between plant emergence and vine kill. Aphids were counted and collected from the underside of six lower leaves from 10 randomly selected plants (from rows near borders). The predominant aphid species in Kimberley was green peach aphid and also relative densities of potato aphid were higher in Kimberly than in Aberdeen. Aphid density also differed significantly among the cultivars with densities on Russet Burbank greater than those on the other two cultivars. Ongoing research aims to test aphids with RT-PCR to determine the proportion carrying PLRV. These data will provide a baseline for aphid and PLRV management in the potato growing area of the PNW.

THE GUAM COCONUT RHINOCEROS BEETLE ERADICATION PROJECT

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The coconut rhinoceros beetle (CRB), *Oryctes rhinoceros*, a major pest of coconut palms, was first found on the Micronesian island of Guam in September, 2007, at the center of the Tumon Bay hotel district. Adult beetles damage and sometimes kill palms when they bore into crowns to feed on sap. Tree mortality exceeded 50% several years after CRB invaded the Palau Islands, which are also in Micronesia and this level of damage may occur on Guam without intervention.. Coconut is not a major crop on Guam, but palms are valuable ornamental plants for Guam's hotel and tourist industry. Following a delimiting survey which indicated that the CRB population was localized along a five mile stretch of Guam's northwestern coast, an eradication project was initiated. Tactics include local quarantine, mass trapping, sanitation, detector dogs, chemical control, and biological control. A short history of the project will be presented followed by a discussion of successes and failures for each tactic.

DEMOGRAPHIC CONSEQUENCES OF DIFFERING DIETARY SEQUENCES IN TWO TEPHRITIDS

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Although dietary resources are not evenly distributed within the environment naturally, agricultural ecosystems maintain predictable resource distributions. The goal of this project was

to determine how well the Melon Fly (Tephritidae: *Bactrocera cucurbitae*) and Oriental Fruit Fly (Tephritidae: *Bactrocera dorsalis*) adults respond to unreliable resource availability by varying the sequence that the flies received a complete (3:1 yeast to sugar) or incomplete (sugar only) diet. For each of the nine sequence treatments, there were three ten day dietary periods beginning at emergence, during which the flies received either a complete diet or incomplete diet. The fourth dietary period, complete diet only, lasted from day thirty until the end of life. To measure reproduction, oviposition sites were made available for twenty days starting at the beginning of the fourth period. Three main results emerged from this study. First, the consequences of a poor diet are the greatest for young flies (<10 days) and least for older flies (>10 days). Second, death rate drops for both species when older flies received a complete diet after being exposed to an incomplete diet. Third, the amount of complete diet had a larger effect on reproduction than the sequence, with the response different for the two species. The differing response of both species to the dietary restriction is likely due to the different demographic characteristics.

MARK-RELEASE-RECAPTURE AND PTERIN-BASED ESTIMATES OF SURVIVAL AND DENSITY OF CANYON FLIES IN THE FIELD

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Canyon flies (Diptera: Muscidae), *Fannia conspicua* and *F. benjamini*, are serious human nuisance pests in the coastal mountains from northern California through Baja, Mexico. Recent work has shown the dominant southern California species, *F. conspicua*, develops in rotting residues of an exotic ground cover, *Aptenia cordulifolia* ("red apple"), and adults are powerfully attracted to carbon dioxide, so they likely need nutrients such as tears from vertebrates. We studied adult *F. conspicua* survival by collecting and marking (different colors of fluorescent dust for each week) large numbers during two consecutive weekly releases in early-mid-July 2009. Flies were collected daily for 16 days after the first release, and every few days following that through 30 days post-2nd release. Marked fly recovery was fairly high, suggesting a local population with perhaps limited dispersal. Heads were processed to determine pterin content and estimate absolute age relative to degree day accumulations. We will present data on adult fly survival determined by both methods (mark-release and pterin-based age structure) and rough estimates of overall population density.

HOST RELATIONSHIPS OF THE EUCHARITID ANT PARASITOIDS (HYMENOPTERA)

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Eucharitidae is the most numerous group within Hymenoptera that is known to attack immatures of a eusocial host, the Formicidae. Eucharitids are found worldwide, with over 475 described species. Morphology, molecules, and shared life history traits unite the Eucharitidae as a demonstrably monophyletic group with three subfamilies: Gollumiellinae, Oraseminae, and Eucharitinae. We present a molecular phylogeny based on a dataset of over 380 taxa from both

the Eucharitidae and its sister group, the Perilampidae. Molecular evidence from a combined-gene dataset (18S, 28S-D2, D3-D5, COI, and COII) is used to assess relationships of the major eucharitid clades.

Eucharitidae are known to attack five subfamilies of ants, and have been found to be prevalent parasitoids among some important ant groups. Here we focus on the wasps attacking the Ponerinae, Ectatomminae, and Myrmeciinae. Patterns of ant-host use will be examined in consideration of the most recent eucharitid phylogeny. We introduce an updated hypothesis of the correlation between the phylogenetic relationships of the parasitoid and host, including conclusions from molecular divergence dating. Estimates from molecular dating studies suggest an origin of Eucharitidae at roughly 65-90 mya, while major ant lineages diverged much earlier, at ~125 mya. Thus, subsequent adaptive host shifts to established ant lineages is proposed as the means of eucharitid diversification.

SURVEY OF PREDATORY MITES IN CALIFONIA AGRICULTURE

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Phytoseiidae is an acarine family of predatory mites found in a variety of ecosystems. Phytoseiids are studied and utilized in agriculture as biological control agents of Tetranychidae, the family of economically important plant-feeding spider mites. More than 2,500 species of phytoseiids have been identified worldwide, 68 of which occur in California. The majority of California species were identified in the 1960s and 70s.

A state-wide survey was conducted to document the current composition of phytoseiid species found on tree, vine and field crops in California's principal agricultural regions. This study represents the two season survey conducted on the Central Coast region which included avocados, cherimoyas, grapes, strawberries, and caneberries in San Luis Obispo, Santa Barbara, and Ventura Counties.

Two *Euseius* species were identified on avocado in San Luis Obispo County; *E. stipulatus* was the dominant species both seasons. *Euseius stipulatus* was introduced to southern California citrus in 1971 and was not known to occur in San Luis Obispo County. *Euseius stipulatus* was also the most abundant species on cherimoya in Santa Barbara and Ventura Counties. Raspberry provided 6 and 7 species in 2006 and 2007, respectively; *Amblydromalus limonicus* was dominant in 2006 and *Phytoseiulus persimilis* in 2007. Koppert Biological Systems is currently evaluating *A. limonicus* for commercial production. Blackberry provided 5 and 6 species in 2006 and 2007, respectively; *N. californicus* was dominant in 2006 and both *N. Californicus* and *A. limonicus* were dominant in 2007. The greatest diversity was found on grape with 7 and 8 species in 2006 and 2007, respectively; *E quetzali* was the dominant species in 2006 and *E. stipulatus* was dominant in 2007. Three species were identified on strawberry; of those, *Neoseiulus californicus* was dominant in 2006 in spite of consistent releases of *P. persimilis. Phytoseiulus persimilis* was most abundant in 2007.

LIFE TABLE BASED ASSESSMENT OF THE IMPACT OF A CLASSICAL BIOLOGICAL CONTROL PROGRAM FOR B*EMISIA TABACI* IN ARIZONA

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A large interagency classical biological control program was initiated in the early 1990s to combat the invasion of the B biotype of *Bemisia tabaci* into the USA. The program was successful in discovering, importing, rearing and releasing more than 30 species/strains of aphelinid parasitoids (primarily *Eretmocerus* and *Encarsia*) from around the world into multiple states. Establishment of several species in each targeted state has been documented. In Arizona, two exotic species have been documented to be established through morphological and DNA-based methods (*Er*etmocerus nr. *emiratus* and *Encarsia sophia*) and these species have largely displaced native aphelinid species attacking *B. tabaci* in the past few years. However, the impact of these establishments and the overall biological control program in Arizona and elsewhere has been poorly documented. From 1996-2008 *in situ* life tables have been constructed for *B. tabaci* on cotton in central Arizona. Analyses of these life tables demonstrate that parasitism varied across years at low to moderate levels but that there is no trend for increasing levels of parasitism since the exotics became established. Additional analyses showed that the irreplaceable mortality supplied by parasitism has not consistently increased since establishment and that parasitism has no explanatory value in predicting total generational mortality. Predation by sucking predators has consistently been the largest source of mortality, has consistently contributed the largest amount of irreplaceable mortality and represents the key-factor explaining variations in total mortality both before and after the establishment of exotic aphelinids.

INTEGRATED MANAGEMENT STRATEGIES IN ARIZONA AND CALIFORNIA TO CONTROL AN INVASIVE STINK BUG, *BAGRADA HILARIS* (BRUMEISTER)

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A new pest of *Brassica* crops, the bagrada bug, *Bagrada hilaris* (Burmeister), was found infesting commercial *Brassica* crops throughout the southwestern desert growing areas of Arizona and California in September 2009. *B. hilaris* was first reported in the U.S. in Los Angeles County, CA in June 2008. It is considered old world in origin; a major cruciferous pest in Africa, Italy, Iran, Iraq, Pakistan, India, and Sri Lanka. Vegetable growers in southeastern California and western Arizona, reported finding small stink bugs (5-7 mm long, 3-4 mm wide) that resembled harlequin bugs, *Murgantia histrionic* (Hahn), damaging emerging seedling and newly transplanted *Brassica* crops in September 2009. By October of 2009, reports of the new stink bug damaging crops were widespread throughout Yuma Valley, AZ and the Imperial, Coachella and Palo Verde Valleys of California. *B. hilaris* was reported during the spring and summer of 2010 on canola, sugarbeet, and alfalfa crops, in home gardens and on weed species such as London rocket, *Sisymbrium irio* L. By the fall of 2010, *B. hilaris* range of crop

infestation expanded to various crops along the California South Coast and in the southern San Joaquin Valley, CA. We are developing integrated pest management practices to control this invasive stinkbug on *Brassica* crops in the southwestern desert region. We will present data from chemical control trial, biological control trials and on the biology of the pest.

DIFFERENTIAL SCANNING CALORIMETRY AS A TOOL FOR STUDYING INSECT METABOLISM

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The study of insect metabolism in response to biotic and abiotic factors has a long history in the field of insect physiology. Isothermal and differential scanning calorimetry (DSC) has been used to determine metabolic rates of numerous organisms. Isothermal calorimetry measures the rate of heat produced at a constant temperature and DSC measures the metabolic heat rate as a function of temperature as the temperature is continuously changed or scanned. Some calorimeters, such as the one used in this study, can be operated in either mode, isothermal or temperature scanning. Metabolic heat rate is directly related to the oxygen use rate in aerobic organisms, but heat rate is easier to measure, particularly in small non-aquatic organisms. CO2 production rates can also be measured by calorimetry to provide additional information on metabolism. Changes in metabolic heat rates can indicate the response of an organism to various stresses, such as temperature extremes, anoxia, and pesticides. In addition, it can be a very useful tool in describing the optimal growth range of an organism as well as the biochemical pathways being used by an organism. We describe the use of differential scanning calorimetry as a tool for studying insect metabolism.

MANAGING 'B' AND 'Q' BIOTYPES OF THE *BEMISIA* WHITEFLIES

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Bemisia tabaci whiteflies have been pests of many crops for many years. However, it wasn't until the late 80s that a new biotype, the B biotype, was introduced to greenhouse crops in the United States. This biotype presented tremendous management problems for the next few years, and since it was genetically different than the A biotype which was already in the United States, it was designated a new species, *Bemisia argentifolii*. Then in 2005 another biotype, the Q biotype, was introduced to greenhouse production via cuttings shipped into the United States. This biotype was resistant to the insecticides that had been developed to control the B biotype. We investigated the efficacy of insecticides against both biotypes to determine if they were

efficacious and how they would impact a population that was initially evenly split between the B and Q biotypes. More insecticides were efficacious against the B biotype. Abamectin, acetamiprid, dinotefuran, spiromesifen, and spirotetramat were among the more efficacious insecticides against the Q biotype. Different combinations of treatments were applied against the 50:50 ratios of the two biotypes, and a greater percentage of Q survived after eight weeks. The Q biotype is more resistant to the insecticides that are most effective against the B biotype; furthermore, the potential for widespread resistance is greater.

THESE LITTLE SUCKERS ARE MITEY PROBLEMATIC IN HOPS

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Spider mites, including twospotted spider mites *Tetranychus urticae*, may be the closest thing to a "ubiquitous" arthropod pest: their geographical distribution is vast (including virtually all of North America) and their host range amazingly diverse (feeding on at least 180 known plant species). Pests of agriculture, horticulture, and urban landscapes, they inflict damage by sucking juices from the plant cells at rates estimated to approach 50% of the mass of an adult female per hour of feeding. In essence, mites "filter feed," extracting the most nutritious cellular contents and directly excreting water and other fluids low in nutrients. At the macroscopic level, damage from mite feeding can cause leaf bronzing, stippling, or scorching. For most horticultural crops, economic loss is caused by a drop in yield or quality due to reduction in photosynthesis. Mite population build-ups are favored by hot, dry, dusty conditions. In short, Pacific Northwest hops—a perennial vine crop grown largely under the hot, dry, dusty condition known as "summer" in most of the hop-growing regions—are an ideal host. (Over 80% of the nation's hops are grown under conditions of heat, water stress, and lack of humidity, including a preponderance in Washington's Yakima Valley and some in Idaho's Treasure Valley; most of the remainder of the nation's hops are grown in the moister, cooler Willamette Valley of Oregon and the northern Idaho panhandle.) Spider mites are well documented as the most important pest in Pacific Northwest hops. Hops are well documented as a crucial flavoring ingredient in beer. And beer is well documented as a key factor in human well being, according to the individuals who consume the 40 billion gallons produced annually worldwide, about 25% of which is brewed with Pacific Northwest hops. The Washington State University Irrigated Agriculture Research and Extension Center in Prosser, WA, USA, has conducted research into optimizing hop IPM including spider mite control over the past few years. Recent work includes field testing candidate compounds for efficacy (as well as observing impacts on non-target species); evaluating rotational programs of sequential applications of candidate miticides for efficacy and to minimize residues; evaluating impact of mite feeding and insecticide phytotoxicity on vine physiology, vine growth, and cone development; and quantifying the effects of mite (and aphid) feeding on the alpha and beta acids that are critical to the flavor components and therefore marketability of hops and their extracts (we are conducting some of the first such tests on the high-alpha hops that are a key component of microbrews and the premium export market). By successfully inducing varying levels of mite population densities (i.e., few or no mites, an intermediate population of mites, and a large population of mites), we have achieved practical results for varying situations. Pest biology and impacts on hop will be discussed, as well as recent research and resulting recommendations for mite control.

EFFICACY OF TWO SPINOSAD-BASED AND ONE METHOXYFENOZIDE-BASED INSECTICIDES FOR *SOLENOPSIS* SP. AND *STRYMON BASILIDES* CONTROL IN PINEAPPLE.

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The rapid expansion of area used for pineapple cultivation has been a significant challenge for those responsible of phytosanitary management programs in this crop in Costa Rica. Phytosanitary programs are based on diverse strategies whose central premise is the use of synthetic agro-chemicals. Insect pest management requires more options, given the great variety of species, the complexity involved in their control, the time from planting to harvest, and the small number of available active ingredients.

In this research, two formulations of the insecticide spinosad were evaluated for control of fire ants (Solenopsis sp.) and the pineapple borer (Strymon basilides). Spinosad is a fermentation product derived from the actinomycete Saccharopolyspora spinosa. Spinosad is a member of the spinosyn family of insecticides and is known to be highly effective against Lepidoptera, , Diptera, Thysanoptera and as well as several species of Hymenoptera. The spinosad formulations evaluated were Justice® 0.015 GB (granular bait) and Entrust 24 SC (suspension concentrate). Both of these products are authorized for use in organic agriculture and are currently in the registration process in Costa Rica. Methoxyfenozide (Intrepid® 24 SC) was also evaluated for control of the pineapple borer (S. basilides). Methoxyfenozide is a bisacylhydrazine insecticide that mimics the insect molting hormone ecdysone.

Both spinosad and methoxyfenozide have minimal impacts on beneficial insects including bees and other pollinators, predators and parasitoids and have an excellent fit in IPM programs.
Eleven trials were performed with spinosad and five with methoxyfenozide at farms located in the areas of Guápiles, Guácimo, Sarapiquí and San Carlos, between 2007 and 2011. The trials done for Solenopsis sp. (five trials) were performed on plots of 1,000 m2 arranged in a random complete-block pattern, with four repetitions. The spinosad treatments included Justice® 0.015 GB at 2 and 3 kg of product per hectare (0.30 and 0.45 g ai/ha) and the commercial alternative (hydramethylnon at 21.9 g ai/ha). Treatments were applied once twelve days after floral induction of the crop. Evaluations were performed at 0, 15, 30, 60 and 75 days after application (DAA). Tuna was used for bait and the total number of ants per sample point was tallied.
The evaluation of spinosad and methoxyfenozide for control of S. basilides included 11 trials. Plots of 100 m2 were arranged in a randomized complete-block design with four replicates. The spinosad treatments (Entrust® 24 SC) varied from 24 to 48 g ai/ha. Methoxyfenozide (Intrepid® 24 SC) was tested from 48 to 120 g ai/ha. Carbaryl at 1344 g ai/ha was included as the commercial standard. Four applications were spaced 10 days apart. Mechanical equipment was used for application and water volumes varied from 2,000 to 3,000 L/ha. Applications began 45 days after floral induction. Percentage of individual fruit found with damage from S. basilides was registered in each experimental unit.

Justice® 0.015 GB demonstrated excellent control of Solenopsis sp. in this study. Both doses evaluated (2 and 3 kg of commercial product per hectare) showed fast action (knock-down) against this pest, registering 100% control at 30 days after application (DAA). Residual effect (75 DAA) was significantly better than that shown by hydramethylnon; all studies confirmed this tendency.

Moreover, Entrust® 24 SC at 36 and 48 gai/ha showed effective control of S. basilides. The percentage of damaged fruit was less than 2%, and no significant difference from carbaryl was noted.

The quantity of spinosad active ingredient evaluated in both studies was between 48 and 73 times less when compared with the commercial treatment doses. This implies a greater level of intrinsic activity, which would represent significant environmental benefit.
Finally, Intrepid® at 96 to 120 gai/Ha showed excellent control of S. basilides with percentage of fruit damaged not significantly different from the commercial treatment.

RED GUM LERP PSYLLID AND OTHER EUCALYPTUS PESTS; WORLDWIDE INVADERS

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Eucalyptus spp. native to Australia are among the most widely distributed plantation-grown trees throughout the world because of their rapid growth, tolerance to a wide range of environmental conditions, and excellent quality cellulose used in high quality paper. Early movement of insect herbivores of *Eucalyptus* was limited, but has accelerated as plantations have expanded. Biological control using parasitoids has provided permanent solutions to problems caused by these herbivores in some parts of the world. As successes are demonstrated in one region, there is increased interest in establishing those natural enemies to other places in the world plagued by the same pest. For example, the early successful biological control of eucalyptus snout weevil in South Africa was expanded to California. Similarly, successful biological control of the eucalyptus longhorned borer was transplanted to South Africa. The red gum lerp psyllid is an example of a new pest species that is established in North and South America and in expanding its range into North Africa. Collaborative efforts are currently underway to extend the biological control program from California into Morocco to reduce the damage to plantations in that country.

THE GLOBAL INVASION OF THE MEDFLY: DISPERSION AND ESTABLISHMENT IN MORE TEMPERATE AREAS

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The Mediterranean fruit fly (medfly), *Ceratitis capitata*, is a highly "virulent" invasive species that threatens the sustainable fruit and vegetable production worldwide. From the ancestral habitats of the sub-Saharan Africa, medfly has dispersed, in less than 200 years, to multitude tropical and subtropical areas including some temperate ones. This paper examines the dispersion dynamics and possible establishment of medfly in the northern coasts of the Mediterranean sea and central Europe, and its population ecology, especially on areas laying within the northern most limits of its current geographic distribution in Europe, aiming at (a) understanding the limits of its dispersion to cooler, more temperate areas, and (b) providing a framework to predict the possible expansion of the medfly geographic distribution as the result of the imminent climatic changes. In Europe, established populations occur in several (mostly) coastal areas of almost all the Mediterranean countries. The northern limits of the geographic distribution of medfly in Europe lay south of the 43° northern latitude. Established populations have been detected in northern Greece, the coastal area of Croatia, Montenegro, and southern France. Sporadic detections of *C. capitata* in several central European countries are attributed to non-established populations introduced via fruit trading from Mediterranean countries. Winter temperatures that inhibit overwintering, host fruit availability and the duration of the fruiting season consists the main barriers prohibiting medfly of being established in the fruit growing areas of central Europe. However, recent climatic changes may relax some of the previous constrains rendering currently unsuitable areas appropriate for medfly establishment.

CHEMICAL ECOLOGY APPROACHES FOR THE HOST RANGE ASSESSMENT OF *MOGULONES BORRAGINIS*, A BIOCONTROL AGENT FOR HOUNDSTONGUE

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Houndstongue (*Cynoglossum officinale* L., Boraginaceae) is a herbaceous, monocarpic facultative biennial plant native to Eurasia that has become invasive in western North America. Houndstongue contains pyrrolizidine alkaloids (PAs) that are toxic to mammals and its burred seeds cause irrigation to rangeland livestock. A biological control program was initiated in 1988 and the sole potential agent currently investigated is the seed -feeding weevil *Mogulones borraginis.* The host range of the weevil has been studied in detail by CABI Europe - Switzerland since 1993: A total of 87 plant species among Boraginaceae, Asteraceae, and Brassicaceae have been investigated in no- and single choice tests. In addition, seed volume measurements were taken to assess whether test plant fruits offer sufficient resources for larval development of *M. borraginis.* More than 90% of test plants were never attacked by *M. borraginis*. Oviposition and/or larval development of *M. borraginis* in pre-release tests was limited to two native congeners of houndstongue and few plant species in a related genus that typically has fruits much smaller than those of houndstongue. In order to further study the restricted host-range of *M. borraginis,* specifically to verify that those plant species that were attacked in host-specificity tests won't be at risk should the weevil be released, we propose a set of chemical ecological techniques, i.e., combined gas chromatographic-electroantennographic detection (GC-EAD) and four-arm olfactometer experiments, to further improve the quality of the current host range data set.

COMPARING SIMPLE VERSUS DIVERSE TRAP CROPS FOR CONTROL OF THE CRUCIFER FLEA BEETLE

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The crucifer flea beetle, *Phyllotreta cruciferae* Goeze (Coleoptera: Chrysomelidae: Alticinae) is an oligophagous pest of Brassica crops. In the Pacific Northwest, many growers rely on Brassica corps as a major component of mixed-vegetable production, and flea beetle damage lowers marketable yields of these crops. In plots both west (Mt. Vernon, WA) and east (Moscow, ID) of the Cascade Mountains, we have been evaluating different species species-compositions of trap crop plantings to draw flea beetles out of broccoli (*Brassica oleracea* L. var. *italica*). We compared single- and mixed-species plantings of the three most attractive trap-crop species identified in a previous field trial (*Brassica napus*, *Brassica juncea*, and *Brassica campestris* L. *chinensis*) for their abilities to attract flea beetles and protect adjacent broccoli. Flea beetle (*P. cruciferae*) populations in trap-crop species were tracked using D-vac suction, while visual observations were used to monitor flea beetle populations and damage in broccoli. We found that broccoli adjacent to diverse polycultures of all three trap-crop species attained the greatest dry weight. Our results thus far suggest that multi-species trap-crops are a particularly effective way to protect broccoli from flea beetle damage.

IDENTIFICATION OF GENETIC MARKERS TO DISTINGUISH WILD AND STERILE MEDITERRANEAN FRUIT FLIES

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The Mediterranean fruit fly, Ceratitis capitata (Diptera:Tephritidae), is a destructive agricultural pest that has spread from its presumed origin in sub-Saharan Africa throughout many tropical and subtropical regions of the globe in recent years. In infested areas, many of the most successful biologically based control programs rely heavily on the use of the Sterile Insect Technique (SIT). For example South Australia, while fruit fly free, experiences outbreaks every few years from endemic populations in Western Australia, and these are eradicated with a combined chemical / SIT program. One challenge that has faced this program, as well as virtually all programs utilizing the SIT method, is the ability to distinguish wild vs. sterile flies captured either during the latter phases, or after the conclusion, of the release program. The ability to make these distinctions accurately and rapidly may be critical for assessing the effectiveness of any SIT program.

The main goal of our study was to develop a molecular technique that would improve the accuracy and efficiency of methods currently available to distinguish flies of different strains, including sterile vs. wild flies. Using a method based on the direct analysis of DNA sequence

variants from the NADH subunit (ND4) gene of the mitochondrial DNA, we identified a single nucleotide change that appears to clearly distinguish the wild flies found in Western Australia from the sterile, released flies derived from the Vienna 7 strain. This marker will be of great help in quantifying the success of the SIT program through the ability to rapidly distinguish whether recaptured flies are of wild or sterile origin.

ELECTRICAL PENETRATION GRAPH (EPG) AS A TOOL TO DEVELOP EFFECTIVE IMP STRAGETIES IN VEGETABLE CROPS: CASE STUDY OF *BACTERICERA COCKERELLI* AND ZEBRA CHIP.

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Zebra chip, a newly emerging disease of potato in southwestern US, Mexico, Central America, and New Zealand is causing millions of dollars in losses to the potato industry. This disease is associated with a previously undescribed species of the bacterium liberibacter, "*Candidatus* Liberibacter solanacearum" (syn. "*Ca*. L. psyllaurous"), transmitted by the potato psyllid, *Bactericera cockerelli* (Sulc). Effective management of this economically important disease will not be realized until mechanisms of how this insect vector transmits this bacterium to potato are elucidated. Electrical Penetration Graph (EPG) monitoring is used to elucidate the stylet probing activities of piercing sucking insects by correlating patterned fluctuations in voltage known as waveforms with salivary sheath termini in host plant tissue. Here in, we report on how EPG was used to study and establish for the first time the stylet penetration behaviors of the potato psyllid feeding on potato. This EPG technique will also help increase understanding of liberibacter transmission by the potato psyllid. Establishment and characterization of *B. cockerelli* waveforms will allow identification of alternative host species which may act as reservoirs for liberibacter. Moreover, EPG waveforms of B. cockerelli could lead to faster identification and development of resistant potato varieties and insecticide screening, strengthening the development of effective IPM strategies involving cultural control, plant resistance, and use of selected pesticides.

ASSESSING THE INCURSION OF ALIEN ANTS WITHIN THE NATIONAL PARK OF AMERICAN SAMOA

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The Samoan archipelago supports a relatively rich ant fauna with at least 42 native and 26 alien species recorded, including the aggressive and ecologically destructive *Pheidole megacephala* (big-headed ant). The distribution and impacts of most of these alien species are poorly known,

particularly in native forest. Results presented are those of an ongoing study within the National Park of American Samoa to characterize the ant fauna and determine the extent to which alien ants have invaded this relatively pristine area. Within the Tutuila section of the park, ants were surveyed at 15 sites during December 3-12, 2010. Behavioral dominance of ants within sites was estimated by measuring ant abundance at baits while an assessment of species richness was made by hand searching and by extracting ants from litter. Overall, 19 native and 15 alien species were identified, with 12.3 ± 0.8 (range 8-18) species found per site. The invasive *Paratrechina vaga*, *Strumigenys rogeri* and *P. minutula* were most widespread, being found at 15, 14 and 13 sites, respectively. *Pheidole umbonata* was the most widespread native ant, found at 10 sites. *Pheidole megacephala* was behaviorally dominant, excluding nearly all other species from baits on the 7 sites where it was found; native *Pheidole* (3 species) were generally co-dominant on the other sites. The mean ratio of native to non-native ants was 2.5 times greater on sites where *P. megacephala* was absent compared to sites where it was found, suggesting preliminarily that *Pheidole megacephala* may reduce native ant diversity.

EVIDENCE FOR AN EGESTION MECHANISM OF INOCULATION OF A SEMIPERSISTENTLY TRANSMITTED CLOSTEROVIRUS BY ITS APHID VECTOR

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Two competing hypotheses have been proposed regarding the mechanism of inoculation of noncirculative plant viruses by their insect vectors: 1) egestion of previously acquired virions, or 2) salivation dislodging virions previously bound to the stylets. Recent work strongly supports the salivation hypothesis as the mechanism of inoculation of noncirculative, nonpersistently transmitted plant viruses, but the mechanism of noncirculative, semipersistently transmitted plant viruses remains uncertain. These two hypotheses were tested using the semipersistently transmitted phloem-limited closterovirus Beet yellows virus (BYV), and its vector, *Myzus persicae*. Feeding behavior of viruliferous aphids was monitored on healthy plants using a DC electrical penetration graph (EPG), and feeding was artificially interrupted at different times to obtain 3 groups of aphids: aphids that engaged only in pathway phase; aphids that engaged in pathway phase followed by waveform E1 (sieve element salivation); and aphids that engaged in pathway, waveform E1, and waveform E2 (sieve element ingestion). The salivation hypothesis predicts inoculation occurs during waveform E1, whereas the egestion hypothesis predicts inoculation occurs during waveform E2 (sieve element ingestion); otherwise there would be nothing in their foregut that could be egested. Only 1 out of 11 viruliferous aphids that engaged only in pathway phase inoculated their test plants, and 0 out of 9 aphids that engaged in pathway phase plus sieve element salivation (waveform E1) inoculated theirs. However, 18 out of 22 aphids that engaged in waveform E2 inoculated their test plants. These results rule out salivation as the likely mechanism for inoculation of BYV, and support the egestion hypothesis. Evidence also indicates that inoculation occurs very early during E2, or within the E1-E2 transition.

ATTRACT-AND-KILL BAIT STATIONS FOR IMPROVED FRUIT FLY (DIPTERA: TEPHRITIDAE) MANAGEMENT IN PAPAYA ORCHARDS

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Bait stations represent an environmentally-friendly attract-and-kill approach to fruit fly (Tephritidae) population suppression. A visually-attractive attract-and-kill bait station was recently developed in Hawaii as a way of protecting the spinosad-containing GF-120 NF Naturalyte Fruit Fly Bait against rainfall. Furthermore, the application of insecticidal baits onto bait stations circumvents the phytotoxicity caused by this bait on some crops and minimizes degradation of spinosad by photolysis. We present here results from various behavioral studies that demonstrate that bait stations (1) enhance the behavioral response of various species of fruit flies to GF-120, (2) extend the period of bait attractiveness for at least one week, (3) allow for quantification, under field conditions, of the period of bait attractiveness to female oriental fruit fly, *Bactrocera dorsalis* and melon fly, *B. cucurbitae*, and (4) provide a standardized way of evaluating bait spray formulations, thus allowing for proper comparisons over time, across fruit fly species, and among geographical areas. From a pest management perspective, results from a large-scale field study conducted in commercial papaya orchards in Hawaii indicate that bait stations provide a simple, efficient and economical method of applying insecticidal baits to effectively control *B. dorsalis* and a safer alternative to foliar sprays.

BIOLOGICAL ATTRIBUTES OF CYAZYPYR™ (DPX-HGW86, CYANTRANILIPROLE): A NOVEL CROSS-SPECTRUM 0 ANTHRANILIC DIAMIDE INSECTICIDE

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Cyazypyr™ (a.k.a. DPX-HGW86 and cyantraniliprole) is a second generation anthranilic diamide insecticide that was discovered and is currently being commercialized by the DuPont™ Company. Cyazypyr™ has a novel mode of action that selectively activates the ryanodine receptor in insect muscles. The biological attributes of selected Cyazypyr™ formulations will be discussed, including spectrum, insect life stage affected, ability to stop insect feeding and protect from plant and disease damage, systemic behavior in plants and fit in IPM and IRM programs.

THE ROLE OF SYSTEMIC INSECTICIDES IN THE MANAGEMENT OF VINE MEALYBUG (*PLANOCOCCUS FICUS*)

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The rapid spread and increasingly severe infestations of the vine mealybug (VMB) continue to represent a formidable challenge to grape production in California. The cryptic nature of VMB on grapevines above and below ground presents a difficult management problem that has been addressed primarily through chemical control. The recent introduction of newer and more selective insecticides gives an opportunity to more fully integrate chemical and biological control and potentially reduce dependency on insecticides while improving IPM sustainability. There are now five neonicotinoid insecticides registered for use in grapes with all but acetamiprid usable as soil-applied systemic insecticides. Field trials conducted in table grapes in 2010 with imidacloprid produced uneven results across vineyards and indicated that conditions for its effective use need to be better elucidated. Imidacloprid titers in grapevine tissue differed significantly among 3 vineyards and had equivocal impact on VMB infestations. Large differences in the solubilities of the four soil-applied neonicotinoids may prove to be important in deciding which insecticide to use in a particular environment (e.g. soil texture). As the newest and perhaps most unique systemic insecticide in terms of its systemic mobility in both phloem and xylem tissues, just a single application of spirotetramat performed exceptionally well against VMB in a heavily infested vineyard. In contrast, other treatment plots required aggressive action using insecticide mixtures in late June to clean up the burgeoning VMB infestation after various insecticide regimens failed to contain VMB earlier in the season.

SYPHRAEA UBERABENSIS: A POTENTIAL INSECT BIOCONTROL FOR INVASIVE MELASTOMES

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Syphraea uberabensis (Coleoptera: Chrysomelidae) is a South American flea beetle whose adults and larvae feed externally on *Tibouchina* foliage and soft stems, causing enough damage to kill small plants. Under quarantine evaluation as a potential biocontrol agent for *Tibouchina herbacea (*Melastomataceae), *S. uberabensis* has been tested on a variety of native and non-native species within the order Myrtales to identify its expected host range in Hawaii. Multi-choice behavioral tests with adult beetles and no-choice tests with adults and larvae indicated a host range restricted to several species within the tribe Melastomeae, all of which are invasive weeds in Hawaii. Preferences were found for feeding and egg laying on two *Tibouchina* spp., *Pterolepis glomerata,* and *Melastoma candidum*, but *S. uberabensis* appeared unlikely to impact the other serious weeds including *Tibouchina urvilleana*, *Miconia calvescens* and *Clidemia hirta*.

We consider the potential for using this biocontrol agent in management of a variety of weedy melastomes.

BIOCONTROL OF MADAGASCAR FIREWEED IN HAWAII: FOREIGN EXPLORATIONS, AND HOST DELINEATION OF TWO ARCTIID MOTHS

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Fireweed, *Senecio madagascariensis* (Asteraceae), which has invaded over 400,000 acres of rangeland in the Hawaiian Islands, is toxic to cattle and horses. Mechanical and chemical control measures are not economically practical and the potential for classical biological control of fireweed in Hawaii appears good because there are no native species in the same tribe as fireweed (*Senecioneae*) and most of them are weeds.

The Hawaii Department of Agriculture, the Maui County and the Hawaii Cattlemen's Association have funded three exploratory trips to southeastern Africa, the native region of fireweed, to investigate the natural enemy assembly of this weed. In South Africa, Swaziland, and Madagascar fireweed occurs in small isolated populations and is not perceived as an invasive species due to the feeding activity of several herbivorous insects and infestation by two rust diseases.

Twelve insects and two pathogens were shipped to the HDOA Containment Facilities for evaluation and host range testing. A yellow rust fungus identified as *Puccinia lagenophorae* from fireweed in Australia, South Africa, and Madagascar was tested on 42 species in eight tribes of Asteraceae. The rust severely infected fireweed, but tests were discontinued when two Hawaiian endemic species were found to be susceptible. The insect agents included five flower-head feeders, three stem borers, two root feeders, and two arctiid moths (Lepidoptera: Arctiidae) whose caterpillars are voracious defoliators. Host testing on seven of these species and a white rust were terminated because of rearing problems or minimal impact on fireweed. Two arctiid moths, *Secusio extensa* from Madagascar, and *Nyctemera apicalis* from South Africa, appear to be adapted to members of the fireweed tribe, *Senecioneae*.

Candidate biological control agents from Africa, bionomics, and host range evaluations of the two arctiid moths conducted to address their possible impact on non-target species will be presented.

SAVING WILIWILI-PART 2: FORTUITOUS BIOCONTROL OF *SPECULARIUS IMPRESSITHORAX* (COLEOPTERA: BRUCHINAE) ON *ERYTHRINA* SEEDS

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Species of the genus *Erythrina* (Fabaceae), are common ornamental trees in streets and city parks; also described as part of folk traditions and indigenous medicine throughout tropical and subtropical regions of the world. The endemic wiliwili tree, *Erythrina sandwicensis* is a key component of the ecosystem in dry land forests of the Hawaiian Islands. The major damage to the wiliwili in Hawaii are caused by two invasive African pests, *Quadrastichus erythrinae* (Hymenoptera: Eulophidae), the Erythrina Gall Wasp and the bean beetle, *Specularius impressithorax* (Coleoptera: Bruchinae). After the successful biocontrol program of EGW the seed damage currently presenting a further threat to the reproductive fitness of the wiliwili populations. During a survey in Africa we discovered a gregarious egg-larval endoparasitoid of *Entedon* sp. n. (Hymenoptera: Eulophidae) a dominant parasitoid in infested seeds of several *Erythrina* species. Before initiating plans for its evaluation in Hawaii, recent survey showed that the same parasitoid has been accidentally introduced but remained undetected since 2003. *Entedon* sp. n., is described from the Hawaiian Islands and Africa for the first time. Field observations in Africa, suggest much lower degree of infestation of *Erythrina* seeds by *S. impressithorax* due to this parasitoid. In addition, three extant ectoparasitoids (*Stenocorse bruchivora* [Braconidae], *Brasema cushmani* [Eupelmidae], and *Goniozus emigrates* [Bethylidae]) and *Pymotes tritici*, (Acarina: Pyemotidae) occasionally attack *S. impressithorax* in infested *Erythrina* seeds from Hawaii. This year the new flush and abundant flowers on wiliwili trees appear for the first time after three years of devastating infestation by the EGW. It is expected that the problem of seed infestations will resurface during the wiliwili fruiting season. Various peculiarities of parasitoid-host relationships of the new *Entedon* species and its potential for curbing *S. impressithorax* seed infestation will be discussed.

DEVELOPMENT OF MONITORING & CONTROL DEVICES FOR INVASIVE SPECIES AND EXOTIC FRUIT FLIES

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Scentry Biologicals, Inc. has been researching and developing devices for insect monitoring and control for over 30 years. Exotic fruit fly and invasive pest detection, delimitation, and control using semiochemicals-based attractants form the foundation of pest management programs. We report a summary and an update of recent research conducted to monitor and control the following emerging invasive pests in the Pacific Region: Light Brown Apple Moth (*Epiphays postvittana*), Coffee Berry Borer *Hypothenemus hampei*, Stink Bug (*Chlorochora ligata*), and exotic fruit flies.

A general practice of monitoring fruit flies in the United States, specifically regions such as California and Florida, entails absorbing an attractant and an insecticide onto a cotton wick and positioning the combination into a Jackson Trap with a sticky bottom. The preparation of the cotton wick is laborious and the users are exposed to liquid insecticides such as Naled (Dimethyl

1,2-dibromo-2,2-dichloroethyl phosphate). Combining the attractant and the insecticide within a polymeric device would minimize exposure to insecticides and eliminate the added task of baiting wicks. Furthermore, we investigated combining attractants of different fruit fly species, to examine if repellency or opposing interactions were observed. Devices that contain multiple active ingredients that attract multiple species would minimize the number of traps requiring maintenance in a monitoring program.

To support this effort of transitioning to a program that would solicit manufactures to supply either attractant formulations alone or combined with a toxicant, a study was conducted on native populations of *Bactrocera dorsalis*, Oriental Fruit Fly and *Bactrocera cucurbitae*, Melon Fruit Fly on the Big Island of Hawai'i. The 8-week trial compared the Scentry Methyl Eugenol Cone and the Scentry Cue Lure Plug combined with synergists, insecticides, and combinations of Melon and Oriental Fruit Fly attractants. The test revealed the all-in-one products present in the study were competitive to the loaded wicks, offering field technicians a viable alternative to the old method of baiting cotton wicks. To determine if combining semiochemical attractants is viable monitoring method, additional refinements of the active loading and further testing need to be conducted.

GETTING IT RIGHT! LESSONS LEARNED FROM UNIQUE UNDERGRADUATE SUMMER RESEARCH PROGRAM

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Research experiences serve as valuable co-curricular activities that enhance undergraduate degree programs, and enable students to be competitive for graduate school admission and in the job market. However, universities offer little, if any, support for co-curricular program development. Program success thus depends on effective self assessment and appropriate program modification based on student feedback. At OSU, we host a NSF supported REU (Research Experiences for Undergraduates) Site program that trains undergraduates in comparative, multidisciplinary research in pollination biology over 10 weeks in the summer. Students are recruited nationwide, and provided background information on bees, plants, ecology, conservation, sampling and statistical analyses. They examine plant-pollinator interactions while rotating through three ecologically distinct sites across the state of Oregon. During the first two rotations, they help with existing projects. In the third rotation they conduct independent research on a specific topic and present their results during a Pollination Conference. Annual program evaluations have identified areas requiring improvement such as clarity in student expectations and increased time for conducting independent research projects. The lessons that have been learned through challenges faced by both student and faculty participants, modifications made annually, and resulting impacts on the program will be presented.

THE IMPORTANCE OF PLACE: DISTRIBUTION MAPPING AND ASSESSING BIOLOGICAL CONTROL AGENTS OF INVASIVE PLANTS IN THE INTERIOR WEST IN THE CURRENT REGULATORY ENVIRONMENT

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As more land managers recognize the potential for weed biological control agents to help them reach weed management objectives, it is increasingly important that entomologists track where insect biological control agents have become established, and what impact they are having on target and non target plants. The National Environmental Policy Act (NEPA) and other federal regulations require federal land managers to assess the effects of management activities, such as biological control agent releases, on the environment. Some federal land managers question if existing procedures are sufficient to adequately address NEPA requirements. The availability of quality monitoring data and distribution maps will be crucial to documenting the impact of biological control agents and insuring that they are available to future generations of land managers.

A CONTRARY PERSPECTIVE TO BUMBLE BEE DECLINES: THE OREGON EXPERIENCE

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Globally, there are reports of declines in native bee populations, especially those of bumble bees, which have been attributed to habitat fragmentation, pesticides and pathogens. However, systematic assessments have not been made in several regions. Our objective was to determine the diversity and abundance of native bees in the Willamette Valley, a rich agricultural region in western Oregon. In studies conducted in crops that bloom in spring and summer, we used blue vane traps for assessment of bees in the landscape, and visual observations for determination of specific foragers on each crop. The studies indicated the presence of thriving populations of a complex of bumble bee species in the region. The results and our speculations for the existence of the 'contrary' situation with respect to bumble bee populations in the Willamette Valley will be presented.

METABOLIC PROFILING: A NEW TOOL IN THE PREDICTION OF HOST-SPECIFICITY IN CLASSICAL BIOLOGICAL CONTROL OF WEEDS?

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Current host-specificity testing for the selection of environmentally safe weed biological control agents is based on the molecular phylogeny of the weed. According to the centrifugal phylogenetic theory, non-target species closely related to a target weed should be at greater risk of attack by a biological control agent than distantly related plant species, as they are biochemically and morphologically more similar and therefore more likely to share the cues used by specialists to select their host. However, whether a molecular phylogeny is a suitable surrogate for phenotypic traits at lower taxonomic levels remains poorly tested. In the model of the potential weed biological control agent *Ceutorhynchus cardariae* Korotyaev (Coleoptera: Curculionidae) for the invasive Brassicaceae plant *Lepidium draba* L., several distantly related plant species were attacked by *C. cardariae* under no-choice conditions while many closely related plant species were not, revealing a disjunct host range. The present study compared the feeding preferences of a specialist (*C. cardariae*) and for comparison an oligophagous (*Plutella xylostella* L., Lepidoptera: Plutellidae) insect testing 47 plant species. Their respective host choices were assessed using different phylograms based either on molecular data, physical attributes (leaf dry matter content, trichome shape and density) and plant chemistry. We hypothesized that the feeding preferences of these two species would be influenced by different sets of cues and that the host choice of both insects does not follow the molecular phylogeny at lower taxonomic levels. Furthermore, we suggest that a phylogram based on phenotypic traits may be a better predictor of host use for both insects.

MINIMUM EFFECTIVE RATES TO CONTROL URBAN PEST SPIDERS

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Spiders are effective insect predators, but are discouraged from structures where their presence may be problematic. People fear spiders and do not tolerate them. Black widow, *Latrodectus spp.* (Theridiidae), and recluse spiders, *Loxosceles spp*. (Sicariidae), may inflict a painful bite and cause allergic reaction and secondary infection. Cellar spiders (Pholcidae) and others do not bite but often build to nuisance numbers around or on homes where their webs are unsightly, cover lights, and clog vents and ducts. Indicative of scale, a large pest management company in California reported up to 90% of summer service calls are to control spiders.

Most labels for insecticides for urban use include spiders, but there are little data to confirm activity and effective rate. Using the marbled cellar spider, *Holocnemus pluchei,* as an indicator species, we determined the minimum effective rate (MER) of contact insecticide spray of several insecticides. Using the MER reduces the potential to contaminate urban water runoff.

Individual field-collected spiders were sprayed directly with a 0.5-L trigger sprayer equipped with a fan nozzle, mimicking common commercial spider control methodology. Spiders were thoroughly sprayed in styrene cups, excess liquid was drained, and the spider immediately transferred to an untreated capped cup provisioned with toweling that absorbed excess spray. Acute knockdown (KD) was observed every 30 min for 4 hrs after which observations were made daily. Allowing for delayed effect, knockdown and mortality were determined for up to 7 days. Each treatment was replicated at least 3 times. The lowest % rate providing 100% moribundity was considered the minimum effective rate (MER).

Insecticides such as imidacloprid and thiamethoxam were not active against spiders, but most were. The MER of many registered insecticides against *H. pluchei* was significantly below their

maximum label rate % (LR_{max}). Most sprays were effective at 1/10 LR_{max} and some were active at < 1/20 LR_{max}. For example, the MER for pyrethrins was 0.012% (1/16 LR_{max}), for permethrin it was 0.025% (1/20 LR_{max}), and for β-cyfluthrin in Temprid it was 0.005% (1/20 LR_{max}). Preliminary trials indicated similar sensitivity against *Latrodectus hesperus* and *Loxosceles reclusa*.

These results indicate that lower than LR_{max} direct spray of many insecticides are effective against urban spiders. Treatment with spider-active insecticides at MER may provide control of spiders while simultaneously minimizing risk and runoff. Multiple treatments over time may be even more effective. Regardless of MER, control of most urban spiders with spray is problematic unless the spider is sprayed directly.

DETECTION, RAPID RESPONSE, AND CONTAINMENT OF COFFEE BERRY BORER, A NEW THREAT TO COFFEE PRODUCTION IN HAWAII

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The coffee berry borer (CBB), *Hypothenemus hampei*, is a major pest of coffee production throughout the world. King Kalakaua imposed a quarantine in 1888 to keep this and other coffee pests out of the Kingdom of Hawaii. The quarantine has been in effect throughout the 122 years since then and has ensured that Hawaii was one of the few coffee production areas in the world that was free of this pest, until now. CBB was detected in the Kona area of Hawaii in September 2010. Upon detection, a statewide delimiting survey was initiated. Results to date demonstrated that CBB is restricted to the Kona area of the Big Island. An intrastate quarantine was implemented to prevent its movement out of the infested Kona area into other coffee growing regions in the state. Pest management options applicable to Hawaii conditions are being researched and used to decrease population levels in the infested area.

PAST, CURRENT, AND FUTURE THREATS OF SOCIAL HYMENOPTERA INVADING HAWAII

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Hawaii's eusocial hymenoptera fauna is composed exclusively of introduced species. No native eusocial species are known. Social hymenoptera in the families Apidae, Vespidae and Formicidae entered Hawaii due to human movement with the greatest invasion occurring over the past 100 years. The history of the establishment of these hymenopterans, their current status and impacts, and concerns and prevention actions against future invasions by other tramp and pest species outside of Hawaii will be presented and discussed.

DOW AGROSCIENCES INSECT MANAGEMENT UPDATE

Jesse M. Richardson[1]

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This presentation will provide an update on recent developments in the insect management product portfolio for the crops business of Dow AgroSciences.

PACIFIC SPIDER MITE CONTROL IN THE LOWER SAN JOAQUIN VALLEY

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Pacific spider mite is a perennial problem for almond growers throughout the San Joaquin Valley. In the lower SJV, mites have historically been controlled by an application of abamectin around May, followed by a contact miticide at hull split. However, there are many new miticide tools available to growers that have allowed a rethinking of how we manage mites. In 2006-7 we conducted field trials in 80 acre commercial orchards that illustrated the new miticides Envidor, Onager, and Zeal were effective in both May and June preventative programs as well as threshold treatment programs compared to abamectin in May. Fujimite was effective in June preventative programs as well as a rescue treatment. So, with these results in 2009-10 we conducted field trials in 300 acre commercial orchards that illustrated similar results as the year before in both the preventative programs as well as the threshold programs but on a larger scale. Therefore, mite treatments may be based on established treatment thresholds and there are viable treatment programs that exist throughout the season.

EVALUATING NEW PEST CONTROL STRATEGIES IN HYBRID POPLARS GROWN UNDER FOREST STEWARDSHIP COUNCIL GUIDELINES

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Hybrid poplars in the Inland Pacific Northwest are a unique short rotation woody crop grown on a 12-15 yr rotation. Two-thirds of the poplar acreage is produced under a certification program (Forest Stewardship Council) that restricts the use of most conventional insecticides. As a result, alternative insecticides must be evaluated within this cropping system to determine their viable addition to the poplar growers' pest control arsenal. We evaluated multiple chemistries (emamectin-benzoate, acephate, chlorantraniliprole, thiamethoxam, clothianidin, and flumioxazin) and strategies (scar protection) to control several of the prominent poplar pests. Efficacy field and feeding trials were conducted within GreenWood Resources's Boardman Tree Farm in Hermiston, OR beginning in 2008. Our results indicated that emamectin-benzoate had limited control of poplar-willow borer (*Cryptorhynchus lapathii* L.), while control by acephate

was dependent on the timing of the application. Both chlorantraniliprole and thiamthoxam controlled the larval stage of the cottonwood leaf beetle (*Chrysomela scripta* Fabricius). We were unable to fully evaluate the strategy of protecting branch scars from western poplar clearwing moth (*Paranthrene robiniae* (Hy. Edwards)) due to extremely low pressure at our study site. A clothianidin cutting dip provided adequate control of larval ten-lined June beetle (*Polyphylla decemlineata* (Say)) when paired with a potato-based carrier polymer (CelGard®). Flumioxazin controlled most weeds for a full growing season in younger stands. Several of the chemistries examined showed promise in their ability to control populations of these common pests and are considered to be good additions to the hybrid poplar pest management toolbox.

IRIS YELLOW SPOT VIRUS IN THE PACIFIC NORTHWEST: RELATIONSHIP BETWEEN OVERWINTERING ONIONS AND ONION THRIPS ACTIVITY

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Iris yellow spot tospovirus (IYSV) continue to be a constraint to onion production in the northwestern states in the inland USA. IYSV is transmitted by the onion thrips (*Thrips tabaci* Lindeman). Control options to reduce the disease impact are limited or not well understood. The lack of resistance to IYSV in commercial onion cultivars combined with prevalence of high vector populations and the availability of abundant virus inoculum could be leading to the severe disease outbreaks observed in recent years. Thrips vectors play a critical role in the outbreaks and volunteer onions were found to be infected with IYSV and served as virus reservoirs. The overlapping seasons of overwintering onions and production sites may provide the "green bridge" for both the virus and the thrips vector will be discussed.

HOST PLANT PREFERENCE, VECTOR INFECTIVITY AND DISEASE STATUS OF PLANTS AFFECT THE SPREAD OF PLANT VIRUSES: RESULTS FROM A MODEL

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Most plant viruses are transmitted by insect vectors. Therefore it is important to understand how insect behavior may influence the spread of plant viruses. In particular, many vectors of economically important plant viruses have been shown to have different preferences for infected and uninfected host plants. Additionally, recent studies suggest that these preferences can change depending on whether a vector is infectious or noninfectious. To understand how this behavior might affect the spread of plant viruses, we create a simple model of disease spread that

incorporates vector preferences for infected and uninfected plants dependent upon the infection status of the vector. Consistent with other models, ours shows that vector preference for infected host plants increases the virus's rate of spread when infected plants are rare, but when the infected plants are prevalent, vector preference for infected host plants decreases the virus's rate of spread. This results in higher levels of infection earlier during a plant virus epidemic, but lower levels of infected plants later during the course of the epidemic. In contrast, if vectors change their preferences after acquiring the virus we no longer see this change in the rate of spread. If vectors exhibit preference for infected plants when noninfectious and preference for healthy plants when infectious, this results in higher rates of spread during all periods of the epidemic than when vectors exhibit no preferences. Data from aphid preference bioassays with the *Barley yellow dwarf virus*-wheat-*Rhopalosiphum padi* pathosystem are used to illustrate the implications of the model.

RUNNING THE RACE WITH SLUGS AND SNAILS: A PACIFIC NORTHWEST RESEARCH AND EXTENSION PROGRAM TARGETING INVASIVE GASTROPODS

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A research and Extension program was developed at Oregon State University targeting invasive terrestrial gastropods in ornamental systems. The Extension program involves trainings for professional Extension educators, growers and landscapers as well as snail and slug information available at the Pacific Northwest Nursery IPM website,
http://oregonstate.edu/dept/nurspest/mollusks.htm.

In 2009, researchers, growers, educators, regulatory representatives, and industry professionals met in Portland, Oregon, to discuss research priorities, coordination of research and outreach, and future plans for managing snails and slugs in ornamentals. A meeting summary is available online, http://oregonstate.edu/dept/nurspest/WRIPMC_Snail__Slug_Meeting_Summary.pdf.

In 2010, research was conducted to compare chemical management tactics currently used by growers with several botanically derived molluscicides that might provide an alternative to carbamates to dis-infest plant shipments with amber snails, small semi-aquatic snails that are established in nursery production facilities throughout the US, and considered plant shipment contaminants. The amber snail chemical trial showed very promising results of two of the botanically-based molluscicides to kill amber snails within one day of application. There was no statistical difference between the percent mortality of Orange Guard, limonene (78%) and Dazitol, capsaisin/allyl isothiocyanate (71%) and the carbamate products, Sevin, carbaryl (90%) and Mesurol, methiocarb (88%). Percent mortality of Slugfest, metaldehyde (37%) and Slug and Snail Away, cinnamon oil (27%) were not statistically different than the untreated control (17%).

ABUNDANCE IS A VIRTUE: MEGADIVERSE ENDEMIC LINEAGES SHOULD GUIDE CONSERVATION

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Insects are generally ignored in conservation planning, in favor of more charismatic, but less diverse, sexy megafauna. Yet, for any fine-scale conservation of the native biota more diverse, perhaps less charismatic, taxa provide more detailed conservation guidance. The Hawaiian Fancy Case Caterpillars, *Hyposmocoma* sp., with over 500 species, are one of the most diverse endemic lineages, and merit conservation attention in their own right. Phylogenetic studies across all Hawaiian islands indicate an unprecedented level of local species endemism, on the scale of individual volcanoes on each island. This data is directly relevant, not only to the conservation of these extraordinary moths, but also to the preservation of the Native Hawaiian ecosystems on which they depend. By using phylogenetic data, generated for evolutionary research, in a conservation context, the ranges and relationships of multiple species can be compared to generate fine-scale measures for multi-species conservation planning that is inclusive of Hawaii's most diverse lineages.

SEASONAL ACTIVITIES AND FEEDING OF GROUND BEETLES IN WESTERN OREGON AGRICULTURAL LANDSCAPES

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Ground Beetles (Coleoptera : Carabidae) are generalist predators that are often abundant in agricultural landscapes and may contribute to regulation of insect pest populations. Understanding why or why not ground beetles affect certain pest populations requires information on the distributions, phenology, and feeding activities of the local ground beetle species. Pitfall traps, systematically arrayed on four Western Oregon vegetable farms, assessed beetle activities both within the crop area and in the field margins. The beetles were live trapped and individuals of several species were taken to the lab to document the number of standardized prey items they would eat, and determine their preference for either fly pupae or weed seeds. Twenty three species were frequently collected. The introduced species, *Pterostichus melanarius,* was the most abundant beetle on all farms and had a peak in activity density in August, but low numbers before July and after September. A collection of less abundant beetle species were most active in spring, contributing to high overall beetle activity densities at times when *P. melanarius* was not present. For most beetles the overall feeding rate in the lab was reduced during the beginning and end of the season of their activity. When given a choice, several species consumed both fly pupae and seeds. Other species only consumed a limited amount of seeds, or none at all, and a few species consumed fewer fly pupae that other similar sized species. Most of the species ranged widely across the farm fields, but a few species had distributions correlated with particular field margin plant communities.

LOCALIZED CHEMICAL TREATMENTS FOR CONTROLLING DRYWOOD TERMITES

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Drywood termites are often difficult to control because of their cryptic behavior and the inaccessibility of infestations within structures. Consequently, entire structure treatments such as fumigation or heat treatments are recommended. Localized chemical treatments are frequently requested by the homeowner because of their concerns over fumigation and cost. With the advent of new chemistries there has been a resurgence in localized chemical treatments.

Laboratory tests were conducted to determine the activity of borates, *d*-limonene, fipronil, imidacloprid, and thiamethoxam against the western drywood termite, *Incisitermes minor*. Suspended concentrate, foam, and dust formulations were tested. Continuous and brief exposure tests indicated that fipronil and thiamethoxam were readily available and provided 100% kill with a few days. The borate and imidacloprid treatments provided delayed mortality over several weeks, but prevented feeding on treated wood surfaces. The *d*-limonene killed termites within an hour, but deposits were only active for about 24 hours.

When termites briefly exposed to fipronil and thiamethoxam treated surfaces were mixed with untreated termites, there was horizontal transfer of the toxicant killing the recipient termites. Grooming and mutual interactions are believed to be the major route of the transfer.
Pieces of infested lumber were monitored with an acoustical termite listening device before treatments. The pieces of lumber were injected with fipronil, *d*-limonene, borate, and thiamethoxam in galleries about 18 inches apart. The boards were monitored weekly for 30 days. The boards were dissected and the number of live and dead termites counted. The fipronil, *d*-limonene, borate, and thiamethoxam provided 91.9, 51.4, 20.3 and 73.2% kill, respectfully.

EFFECTS OF POLLEN QUALITY ON HONEY BEE NUTRITIONAL STATUS, COLONY GROWTH, AND IMMUNOCOMPETENCE

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Nutritional stress is one among several potential factors attributed for colony collapse disorder. In the wake of deteriorating honey bee health, honey bee nutrition has attained greater importance. Pollen is the sole source of protein for honey bees and is vital for their development and survival. Each year large numbers of colonies from all around the country are shipped to California for almond pollination, where bees predominantly rely on almond pollen to fulfill their protein requirement. Little is known about effects of single source pollen consumption for extended periods on honey bees. Here we examined and compared the effects of single-source pollen consumption versus multi-source pollen on honey bee nutritional status, colony growth and immunocompetence. Six frame nucleus colonies were used for this experiment. A large flight cage partitioned in segments was used for this experiment. Colonies were equalized before

start of the experiment and all existing pollen was removed. There were two treatments: 1) single-source pollen and 2) multi-source pollen. Each week twenty nurse bees were obtained from each colony for estimating hypopharyngeal gland protein. Comb area occupied by brood and immunocompetence of the bees were also measured. Preliminary results indicate that nurse bee hypopharyngeal gland protein content, colony growth and immunocompetence in single source pollen treatments were significantly low compared to multi-source pollen treatments ($P < 0.01$).

SYSTEMATICS OF THE GENUS *BACTROCERA* (DIPTERA: TEPHRITIDAE) BASED ON MITOCHONDRIAL AND NUCLEAR GENES

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Tephritid flies in the genus *Bactrocera* are some of the most economically damaging crop pests in Hawaii. Although only three species occur in Hawaii, they can attack over 166 host crops and cost the state millions in the form of crop damage and loss of trade. There are over 500 species within the genus but the most pestiferous group is the *Bactrocera dorsalis* complex, with 10 of its 75 species of economic importance. Hawaii is at constant risk of invasions from this genus due to active trade and international travel. Because different species and even populations of *Bactrocera* may have different host preferences and ecological tolerances, new invasions could result in significantly more damage and challenges for control.

The species taxonomy in *Bactrocera* is not yet fully understood, with many species with unknown hosts. Morphology is of limited use for quarantine identifications as many species are separated by subtle morphological differences, hence very hard to distinguish. A robust understanding of *Bactrocera* species diversity and boundaries is needed to help prevent future invasions, predict the agriculture threat of new invasions and apply the best control strategies for different species.

We developed primers to amplify and sequence three genes for the systematic analysis of *Bactrocera*, including both mitochondrial and nuclear genes. We sequenced these genes for *Bactrocera* species from West Africa, French Polynesia, Hawaii, Cambodia, Thailand and Laos. Data were analyzed using Maximum Likelihood and Bayesian Analysis to understand the evolutionary history and relationships of these species.

PIAKEY: INTERACTIVE IDENTIFICATION GUIDE TO INVASIVE ANTS OF THE PACIFIC ISLANDS

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PIAkey is an interactive, multimedia, user-friendly identification guide to ants species that have been introduced to the Pacific island region. PIAkey is designed primarily to assist non-specialists, such as quarantine officials, with the early detection of invasive ant incursions, but is also targeted towards ecologists, conservationists and other biologists with little taxonomic backgrounds. The guide diagnoses 44 ant species in 21 genera, including highly destructive species such as the Little Fire Ant (*Wasmannia auropunctata*), the Red Imported Fire Ant (*Solenopsis invicta*), and the Yellow Crazy Ant (*Anoplolepis gracilipes*). The identification resource includes a matrix-based Lucid3 key illustrated with line drawings and high-resolution digital images, an illustrated glossary of morphological terms, and video clips for many of the included species. Fact sheets for each species include sections on biology, diagnostic characters, comparison charts with similar species, image galleries, nomenclature, and references and links. Current work is focused on expanding the taxa to include species introduced into the continental United States and integrating species-level content into larger web-based projects such as Antweb and the Encyclopedia of Life. PIAkey is deployed on the internet <http://keys.lucidcentral.org/keys/v3/PIAkey> and available in CD-ROM format upon request.

ECOLOGY OF *DROSOPHILA SUZUKII* IN THE CHERRY PRODUCING REGION OF JAPAN

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Drosophila suzukii is one of the most serious pests of cherry and berries in Japan. *D. suzukii* attacks healthy ripening cherry fruits, and it is difficult to distinguish damaged from undamaged fruits. As such, damaged fruits are often mistakenly shipped to market. In addition, because cherry is a high value crop, fruit damage by *D. suzukii* is a serious problem for cherry producing farmers. It is essential to clarify the ecology of target pest species to establish effective pest management methods. In this study, the following aspects of *D. suzukii* biology and control are summarized: (1) scope of occurrence, (2) the ability to attack healthy ripening fruits, (3) seasonal variation in emergence, (4) host crops, and (5) pest control methods.

SYNGENTA CROP PROTECTION INDUSTRY UPDATE: CROP PROTECTION INSECTICIDES

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Each year, Syngenta Crop Protection, LLC., registers new insecticide products, adds section 3 and 2ee label updates to existing labels, approves section 18 and 24c requests, and otherwise expands label uses of its insecticide portfolio. This presentation provides information covering new label additions and section 3 updates that occurred from January 2010 through March 2011. The focus will be with crops produced in the ESA Pacific Branch region. The presentation

covers Crop Protection products; Professional Products changes will be provided in a separate paper.

EVALUATING USE OF ETHANOL-BAITED TRAPS AND ETHANOL-INJECTED TREES AS A TRAP CROP STRATEGY AGAINST AMBROSIA BEETLES.

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Ambrosia beetles, *Xylosandrus crassisculus* and *Xylosandrus germanus*, are serious pests of woody plant material grown in commercial nurseries in much of the eastern half of the US. *X. crassisculus* is the dominant species in Virginia and Tennessee; *X. germanus* is dominant in Ohio. Ethanol-baited traps determined that peak adult emergence for both species occurred from late March to early May in Virginia, Ohio, and Tennessee, coinciding with maximum daily temperatures exceeding 22C for several consecutive days. Data were used by nurserymen in each state to improve timing of insecticide applications to reduce injury. Additional experiments refined use of ethanol attraction with injection of live trees. Tree injection experiments showed that 90% concentration attracted the largest number of beetles. Mixed results for reducing ambrosia beetle attacks were obtained when reduced risk insecticides were evaluated using injected trees. In addition, one year of data suggests that ambrosia beetle host preference varies among tree species after injection with ethanol. Field studies suggest that ethanol-injected trees could be used as trap trees in commercial nurseries to protect saleable trees from attack.

INVASIVE PEST CHALLENGES TO AN INTERNATIONAL FRUIT COMPANY

Michael Seagraves

Driscoll Strawberry Associates, Watsonville, CA 95077

Driscoll's is involved in breeding, growing, and packing/shipping strawberries, raspberries, blackberries, and blueberries on five continents. Invasive pests impact the company by presenting pest management challenges in production, creates barriers to export markets, and slowing the movement of germplasm. This talk will illustrate through case studies the problems that are created by invasive species from quarantines to shifts in pesticide usage.

MANAGING THE INVASIVE *DROSOPHILA SUZUKII,* A NEW PEST OF OREGON CHERRIES

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The spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is an invasive insect that was first observed in North America on the coast of CA during 2008. It was detected in blueberries in the Willamette Valley, OR in Aug 2009. Shortly afterwards, adult SWD were captured in traps baited with apple cider vinegar (ACV) in Sep-Oct. 2009 in cherry orchards in Hood River and The Dalles, OR. Representatives from the cherry industry met in March 2010 and devised a SWD management plan for cherries. This included developing lists of potentially effective materials and protocols for their use if SWD were detected in OR cherry-growing districts. Comprehensive trapping for adult SWD was initiated in 2010 in Hood River and The Dalles, OR using modified clear 32 oz plastic containers baited with ACV. Adult SWD females were captured in traps in both districts before males were found in traps. Abundance of SWD in traps was low throughout cherry harvest but increased rapidly from Sep-Dec. Efficacy studies combined field treatment and lab assays. Tests with aerial applied malathion ULV yielded promising results and use recommendations. Assays using airblast sprayed cherry leaves and fruit indicate that products containing spinosad, spinoteram, lambda-cyhalothrin, or malathion were effective. Results of assays using fruit treated with acetamiprid, imidacloprid or cyazypyr revealed that these actives provided systemic activity and moderate knockdown of SWD.

CAPTURE PROBABILITY OF RELEASED MALES OF TWO *BACTROCERA* SPECIES IN DETECTION TRAPS IN CALIFORNIA

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The genus *Bactrocera* (Diptera: Tephritidae) includes ≈ 70 polyphagous species that are major pests of fruit and vegetable crops. Most *Bactrocera* species have limited geographic distributions, but several species are invasive, and many countries operate continuous trapping programs to detect infestations. In the United States, California maintains ≈ 25,000 traps (baited with male lures) specifically for *Bactrocera* detection distributed over an area of ≈ 6,400 km^2 (2,500 miles^2) in the Los Angeles area. Although prior studies have used male lures to describe movement of *Bactrocera* males, they do not explicitly relate capture probability with fly distance from lure-baited traps; consequently, they do not address the relative effectiveness of male lures in detecting incipient populations of *Bactrocera* species. The objective of this study was to measure the distance-dependent capture probability of marked, released males of *Bactrocera dorsalis* (Hendel) and *Bactrocera cucurbitae* (Coquillett) (methyl eugenol- and cue lure-responding species, respectively) within the detection trapping grid operating in southern California. These data were then used to compute simple probability estimates for detecting populations of different sizes of the two species. Methyl eugenol was the more powerful attractant, and based on the mark-recapture data, we estimated that *B. dorsalis* populations with as few as ≈ 50 males would always (> 99.9%) be detected using the current trap density of 5 methyl eugenol-baited traps per 2.6 km^2 (1 mile ^{2}). By contrast, we estimated that certain detection of *B. cucurbitae* populations would not occur until these contained ≈350 males. The implications of the results for the California trapping system are discussed, and the findings are compared with mark- release recapture data obtained for the same two species in Hawaii.

RISK ASSESSMENT OF *EUCALYPTUS*-FEEDING INSECTS AS AN ECOTERRORISM WEAPON

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Widely planted across the planet, trees of the Australian genus *Eucalyptus* have been both loved and hated. Despite their benefits to industry and ecosystem function, opposition to *Eucalyptus* plantations is strong, occasionally becoming violent. The trees are seen as encroaching on pasturelands (as in Portugal and Thailand), as being tools of exploitation by foreign nations (as in China and Brazil), or simply as being foreign plants that do not belong. The latter nativism is common in California, where *Eucalyptus* has been planted to such an extent over the last 150 years that one could hardly picture the state without it's extensive *Eucalyptus* forests. Indeed, research has shown that eradicating the trees would be an ecological and aesthetic mistake for the state, but not everyone is convinced. Organisms native to Australia that are pests of the *Eucalyptus* forests there could conceivably be brought into California or other nations illegally by concerned individuals or groups in an effort to eradicate the trees. Such an act falls under the category of eco-terrorism. Likely target insects include leaf beetles, pergid sawflies, and lerp psyllids; and hearsay evidence exists that these have been deliberately introduced in California already. Far more troubling is the potential for phasmids to be released. Species such as *Didymuria violescens* can reach plague-like sizes in Australia and have been implicated in Eucalypt dieback. Furthermore, the active trade of phasmids as pets in the US and Europe provides a readily available, albeit still illegal, source of these organisms. Lastly, non-native phasmids have already been spotted in Southern California, so the accidental or intentional release of a phasmid there is not impossible. The high likelihood of phasmids being used as instruments of eco-terror should not be overlooked, and institutions housing such organisms should keep track of loaned phasmids and dispose of eggs properly.

A VIEW FROM THE TRENCHES: A KONA COFFEE FARMER'S PERSPECTIVE ON THE INVASION

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Hawaii is the only state in the US that grows coffee. Until the discovery of Coffee Berry Borer (CBB), *Hypothenemus hampei*, in Kona, it was also one of the last pest-free coffee regions in the world. In September 2010, the seasonal harvest had begun when the pest was identified. With the crop rolling in, nearly 30% of farms began to report moderate-to-severe damage to the specialty Kona coffee crop. As news quickly spread, farmers, scientists and government officials scrambled to come to terms with the changed reality. Growers who had never heard of "Integrated Pest Management" found themselves attempting to implement alien techniques. Access to scientific journals and worldwide industry practices was limited as the primary documents were in Spanish. And to compound all these issues, the only effective pesticide *Beauveria bassiana*, was illegal. As we prepare for the 2011 growing season, we are still attempting to grasp the true cost of the beetle. Will we be able to minimize crop damage

effectively? How will we balance added labor and monetary costs? And what will happen to the stellar reputation of Kona coffee?

SOME ECOLOGICAL ASPECTS ON THE PHENOLOGY AND DEVELOPMENT OF GRAPEVINE SCALE IN VINEYARDS IN THE CANBERRA REGION, AUSTRALIA.

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Grapevine scale *Parthenolecanium persicae* (Fabricius) field infestation poses an intractable problem in Australian viticulture, widespread in most grape-growing regions. The occasional outbreak of this pest highlights the vulnerability of grapevines under certain predisposing ecological conditions such as lack of natural enemy effectiveness, favourable weather conditions, plant stress and farming practices. Phenology of grapevine scale on grapevines in the Northern and Southern Hemispheres is similar, deviating by six months; oviposition occurs in spring, crawler development commences in summer, second and third instars development in Autumn and subsequent diapause of third instar in Winter. In some Australian vineyards mainly in the Canberra region, Southwest New South Wales, there is considerable variation in the grapevine scale infestation on grapes. However, the population dynamics of grapevine scale in Australian viticulture is not fully understood. Although various management practices are integrated, varietal tolerance and/or resistance has not been considered in grapevine scale management. Plant quality and weather variations are important selection pressures acting on the fitness of grapevine scale. Therefore, some aspects of field infestation and population dynamics of grapevine scale relative to varietal differences and farm management practices observed in the last six months will be discussed.

MANAGEMENT OF INSECT-TRANSMITTED PLANT PATHOGENS: DEFINING CONDITIONS FOR SUCCESFUL ROGUING WITH A SIMULATION MODEL

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Roguing (the replacement of infected plants with healthy plants) is commonly used to manage the spread of insect-transmitted plant pathogens. Roguing has two potential benefits. First, removing an infected plant eliminates a source of inoculum, potentially slowing pathogen spread. Second, as infected plants often die or produce reduced yields, replacing an infected plant with a healthy plant may increase economic returns. Whether or not the benefits of roguing are realized depends on characteristics of the pathosystem and the efficiency of the roguing program. To better understand how characteristics of the pathosystem and roguing program interact to affect pathogen spread, a spatially-explicit simulation model was constructed. Sensitivity analyses indicated that roguing slowed pathogen spread provided that infected plants were removed shortly after inoculation and that roguing was coordinated over large spatial scales. The extent to which roguing increased yields depended on assumptions associated with yield loss due to

infection and rates of pathogen spread. In cases where infected plants produced no useable yield, roguing generally increased yield. In cases where infected plants produced useable yields, some parameter combinations resulted in scenarios where roguing decreased yield.

TO SPRAY OR NOT TO SPRAY? EVALUATING NON-TARGET IMPACTS ON BUMBLE BEE POLLINATORS

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Pesticides are a common tool used in insect pest management programs. Hence, pollinators in cropping systems like natural enemies need to co-exist with pesticides or perish. Historically, honey bees have attracted the most interest in evaluating the toxicological effects of pesticides on bees. Accordingly, agriculture pesticide label precautions regarding application rates and timing for protecting pollinating insects have been established based on honey bee responses to pesticide exposure. However, given the differences in physiology, life history, and foraging behavior of bees, label precautions developed solely on honey bee data may not be appropriate for protecting wild pollinators such as bumble bees. The objective of this study was to evaluate the toxicity of field concentrations of a fungicide and five insecticides used in two important bee-pollinated crops produced in the Pacific Northwest, highbush blueberry (*Vaccinium corymbosum*) and red clover (*Trifolium pratense*). In separate laboratory bioassays, wild caught queen and workers of the dominant native bumble bee, *Bombus vosnesenskii*, were exposed to pesticide residues on treated plant material. Results of this study indicate that the residual toxicity of pesticides varied between queens and workers and also among chemicals. The fungicide, pyraclostrobin/boscalid, was found to be toxic to queens as mortality ranged from 17% to 84% after 72 hours of exposure. Queens exposed to the reduced risk insecticide, spinosad, exhibited a reverse-dose response as the highest mortality (75%) occurred in the lowest concentration. The neonictinoid, imidacloprid, was also considered toxic to queens as mortality ranged from 21% to 63% while no negative effects were observed for workers. Variation was observed in worker responses to organophosphates, as oxydemeton-methyl did not produce negative effects while chloropyrifos was highly toxic resulting in 100% mortality. Similarly, the pyrethroid, bifenthrin, was also highly toxic resulting in 100% mortality of workers. These results highlight the susceptibility of native bumble bees to pesticide exposure and the need for applications of pesticides to be made during pre or post bloom for crops. Implications of the response of native bees to pesticide residues and the sustainability of pollination services in cropping systems and wild habitats will be discussed.

POLLEN FORAGING BEHAVIOR OF NATIVE BUMBLE BEE COLONIES IN MASS FLOWERING RESOURCES

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The European honey bee, *Apis mellifera*, provides pollination services for diverse crops, but parasites and diseases have reduced the availability and increased hive rental costs. Thus, there

is interest in evaluating the efficacy of wild bees, particularly bumble bees, as alternative pollinators. The objective of this study was to determine effects of colony size on the pollen foraging behavior of the native bumble bee, *Bombus vosnesenskii,* in the presence of mass flowering resources. Lab-reared colonies, initiated by collection of wild queens, were partitioned into two size classes based on developmental stage, and placed adjacent to a flowering red clover field in western Oregon. To determine impacts of colony size on foraging behavior, individual bumble bee workers from early and middle developmental stage colonies were observed during peak foraging periods. A paired t-test indicated a significant difference between size classes, as foragers from early colonies made a greater amount of pollen foraging trips, when compared to middle stage colonies ($P = 0.002$). To examine resource utilization, pollen pot samples were extracted from colonies weekly, weighed, and analyzed for floral composition. A two-sample t-test indicated a significant difference during the last two weeks of sampling, as middle stage colonies had the greatest amount of stored pollen when compared to early colonies ($P = 0.005; < 0.001$). While, both collected diverse pollen types, early colonies were more specialized on red clover. Relationships of colony size with resource abundance, and implications for sustainability of pollination services in agricultural and native habitats will be discussed.

QUANTIFYING ARTHROPOD DIVERSITY IN THE SELKIRK MOUNTAINS OF NORTHERN IDAHO AND EASTERN WASHINGTON

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The University of Idaho, in conjunction with Idaho Department of Fish and Game and the United States Forest Service seeks to quantify biodiversity within the Selkirk Mountain Range of Northern Idaho and Western Washington. The area contains the only known population of woodland caribou remaining in the lower forty-eight contiguous states and has been hypothesized to represent a refugium for cold-adapted species of invertebrates. As part of this project, beetle populations have been surveyed using pitfall traps and Lindgren funnel traps. The primary taxa of interest are ground beetles (Carabidae), but a full description of all insect species will be completed. Additionally, gastropod populations are being captured and identified due to the lack of data available on this group and their contributions to the overall diversity within the terrestrial invertebrates. In addition to providing a measure of biodiversity at several trophic levels, the completed project will quantify beetle and gastropod populations through time and space; this will allow researchers and managers to identify related and sensitive areas with regard to potential species of concern within the study area. These data will also allow for analysis of effects on populations by: land management activities, remoteness of sample unit, relationship to both flora and macro-fauna communities, and weather conditions, among others. Though still in its early stages, preliminary data will be presented for discussion.

USE OF LABORATORY AND FIELD EXPERIMENTS TO ASSESS SPECIFICITY OF PROSPECTIVE WEED BIOLOGICAL CONTROL AGENTS

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A series of laboratory and field experiments were conducted to assess the potential risk of *Ceratapion basicorne*, a weevil that attacks roots of yellow starthistle. The occurrence of attacks on nontarget plants in laboratory no-choice experiments raised concerns about potential risk to such plants. Field experiments in Turkey showed that one of these plants, safflower, was never attacked under natural conditions. Although this was sufficient to convince TAG members that the insect is safe to release, APHIS did not issue a release permit. This suggests a serious need to reassess the type of information required to obtain a release permit.

SHORT-TERM PHYSIOLOGICAL RESPONSE OFA NATIVE HAWAIIAN *HIBISCUS* PLANT TO INJURY BY THE EXOTIC *SOPHONIA* LEAFHOPPER

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A small set of leafhopper species are known to cause hopperburn on their plant hosts. *Sophonia orientalis* (= *Sophonia rufofascia*), is one such species, causing hopperburn injury on many plants after introduction to the Hawaiian Islands. We studied the short-term gas exchange response of a native plant, *Hibiscus arnottianus*, following a two-day exposure to *S. orientalis* with three questions. First, does the injury affect rates of net photosynthesis and transpiration? Second, if photosynthesis is affected, is it the result of end product inhibition? Finally, does injury affect respiration rates of the leaves? Using a LI-COR 6400, we compared the response of leaves caged with three leafhoppers to the response of caged (control) leaves and uncaged leaves. We found that injury resulted in a significant 40% loss in net photosynthesis and a significant 33% loss in transpiration rates (P=0.01-0.03), with no visible difference in discoloration of leaves. Assimilation-Ci curve analyses suggest that the reduction in photosynthesis is the result of end product inhibition, and not simply the closing of the stomata. Finally, no difference was found in respiration rates on injured and healthy leaves. These results contrast with other hopperburning species, such as potato leafhopper, *Empoasca fabae*, and brown planthopper, *Nilaparvata lugens*.

POTENTIAL FOR BAITS AND NEST DRENCHES TO ERADICATE ARGENTINE ANT ON SANTA CRUZ ISLAND

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Santa Cruz Island, the largest island off the California coast is home to over 150 native plant and animal species, many of which are endemic and only occurring on one or several of the Channel Islands. The Argentine ant was first reported on the island in 1996 and is now well established in three distinct areas across the island. Toxic baits for Argentine ant control have been utilized in many different types of residential and commercial situations, but their use in natural settings has been more limited. In preparation for a future Argentine ant eradication effort on Santa Cruz Island, we carried out field and laboratory tests to determine the potential efficacy of an experimental thiamethoxam liquid ant bait and Xstinguish™ ant paste bait. Pre-treatment and post-treatment ant counts at monitoring vials indicated that there was a 76.2% reduction with thiamethoxam bait and 82.9% reduction with paste bait at 30d. The feasibility of a "search and destroy" strategy incorporating nest drenches and spot treatments with "reduced-risk" botanical pesticide EcoExempt™ IC^2, was also tested. The potential efficacy and challenges inherent to these methods in this environmentally sensitive setting are discussed.

ENGAGING NON-MAJOR STUDENTS IN ENTOMOLOGY

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World of Insects (PEPS 250) is an introductory entomology course primarily for non-majors. In the University of Hawaii system, World of Insects has a special designation as a writing intensive course which means that assessment is based predominantly on written assignments. Students are required to take a number of these writing intensive courses before they can graduate. The majority of students enrolling in this class are taking it primarily because it is writing intensive and it fits in their schedule. For the most part they do not have an interest in insects. The challenge in teaching this class is to find ways to engage students with the subject matter. In teaching this class I have used a variety of ways to attempt to do this. The students are required to participate weekly in an online blog and online discussion. These are followed up with discussion in class. In lectures, YouTube and other videos are used extensively. Four other assignments including a creative composition are also designed to encourage students to engage with the subject matter in a personal way. These aspects of this course and my evaluation of what worked and what didn't work well will be presented in the symposium. The student feedback on these assignments and the course will also be presented.

Funding to develop this course for full-online delivery has recently been awarded and work has begun to offer this course online in Spring semester 2012 (Jan-May). The issues associated with the transition from a full face-to-face with some online activities to no face-to-face interaction will be discussed.

ENTOMOLOGY CURRICULUM AUSTRALIA: A COLLABORATIVE PROJECT TO DEVELOP ONLINE ENTOMOLOGY COURSES

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The Australian experience – and perhaps an international trend – is that institutions with historical research and teaching strengths in entomology are tending to reduce the number of entomology-based subjects on offer. Professional entomologists in Australia are becoming increasingly concerned that the depth and diversity of entomological education is in rapid decline. This decline threatens future capacity to deal with national research priorities such as protecting Australia from pest incursions as well as wider challenges relating to sustainable food production. Funding from the Australian Learning and Teaching Council and other sources has enabled entomologists at number of tertiary institutions to collaborate and develop four distance-based tertiary entomology subjects that can be taken as non-credit subjects or through cross-institutional enrolment by students anywhere in Australia. This group of courses has been badged as the Entomology Curriculum Australia (ECA). The subjects are media-rich and the majority of assessment items require students to engage in hands-on entomological experiences. Students from across Australia are enrolling in these courses. The web page, www.entomology.edu.au has proved useful as an information point for the curriculum as well as providing more wide-ranging information about entomology in Australia. The courses were offered for the first time in 2010. The uptake of these courses and plans for the future will be presented. Together the subjects provide knowledge that enable graduates to enter into postgraduate study or become well-placed to work in relevant industries such as biosecurity and quarantine.

ECOLOGY AND GENETICS OF THE INVASIVE ARGENTINE ANT

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Biological invasions are a leading threat to biodiversity, agriculture and the economy. Of the many introduced organisms, ants are over-represented with 5 species considered among the top 100 invasive species worldwide. A major challenge of invasion biology lies in the development of a predictive understanding of invasion processes, yet this is inherently difficult because different characteristics may be important at different stages of invasion. I will use the invasion history of the highly invasive Argentine ant (*Linepithemahumile*) as a case study to untangle the

mechanisms of success for invasive ants in each of the three distinct stages of invasion: opportunity, establishment and spread.

USE OF POPULATION MODELS FOR PROTECTION OF BIOCONTROLS IN IPM AND ENDANGERED SPECIES

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One of the major elements of IPM is to use selective pesticides that are more damaging to pest species than to beneficial species. Several approaches have been developed to determine the compatibility of biocontrols and insecticides and they are often based on acute mortality estimates and/or limited measures of effects on reproduction. In most cases, measures on individuals are taken, not populations. However, what we want to protect are populations. We need an approach that takes into account the total effect (lethal and sublethal) of insecticides at the population level. In this paper, we will present a modeling approach that can be used to determine the effects of insecticides on biocontrols and to protect threatened and endangered species. The method consists of simple stage-based stochastic matrix models based on life history data and insecticide susceptibility. The models are designed to determine whether a biocontrol agent will go to extinction during a growing season based on insecticide exposure.

EVALUATING THE IMPACT OF GRADUATE STUDENT CONTRIBUTIONS TO IPM: A "PHYLOGENETIC" APPROACH

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In order to estimate the extent to which graduate student research impacts the field of integrated pest management (IPM), a pseudo-phylogeny was created. A cladogram of sorts was generated beginning with a limited number of nodes, represented by current faculty recognized as preeminent researchers within the IPM community. The contributions of their respective graduate students over the years were examined, focusing on the range of arthropod pests and agricultural systems studied and the resulting impacts to the field of IPM. This information will be extrapolated to demonstrate the significance of the contributions of graduate student researchers.

PHEROMONE-BASED MONITORING OF APHIDS IN CALIFORNIA DRIED PLUM ORCHARDS: COMPARISONS AMONG TRAP TYPES

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A study comparing traps for monitoring male aphids using sex pheromones was conducted in California dried plum orchards. Four trap types were examined in the study: clear water traps, yellow sticky card traps (Pherocon® AM/NB, Trécé, Inc.), white sticky traps (Pherocon® V Tent Trap, Trécé, Inc.) deployed as two-sided sticky cards, and white delta traps (Pherocon® IIB, Trécé, Inc.). Each of the four trap types was represented twice in the experiments, once as a pheromone-baited treatment and once as a no-pheromone control. All pheromone-baited traps were treated with a 1:1 ratio of the aphid sex pheromone components (4a*S,* 7*S,* 7a*R*)-nepetalactone and (1*R,* 4a*S,* 7*S,* 7a*R*)-nepetalactol using polyvinyl chloride rope dispensers. Traps were compared, evaluating effectiveness, selectivity, convenience of use, ease of processing, correlation with subsequent population and damage measures, and economics. Results of the study will be presented and management implications discussed.

INSECTICIDE MANAGEMENT OF THE SPOTTED WING DROSOPHILA ON SMALL FRUITS IN WASHINGTON STATE

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Spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura) is a direct pest of maturing small fruits in the Pacific Northwest. The presence of SWD larvae in the fruit accelerates softening and promotes premature fruit rot, rendering machine harvesting impossible for fragile fruits. With a rapid generation time, a lengthy list of alternative host fruits, and the fruiting season falling well within the seasonal active period of *D. suzukii*, it remains a devastating threat to the $100 million small fruit industry in Washington. Field observations in 2010 indicated cover spray(s) in June bearing strawberry are easily applied with conventional ground sprayers. The traditional red raspberry pyrethroid clean-up spray, applied 3-4 days before first machine harvest, or tank mixed with a neonicotinoid, OP or spinosyn will provide 7-14 days of preventative contact and systemic control until apple vinegar cider traps indicate threshold populations require another preventative application. Similar treatment regimens for older blueberry fields are very problematic with traditional ground equipment because of their fruit load, size of plants and current row spacing. In 2010, mid- and late season Northern Highbush varieties required protective preharvest ripening fruit and harvest ripe applications that are dictated by field age and over-ladened maturing fruit branches. A list of effective insecticides, including new chemistries and rotation partners addressing insect resistance management and pollinator conservation, is necessary for the 2011 season to prevent economic losses by these industries.

PHENOLOGY AND FUNCTIONAL ROLES OF THE EUROPEAN EARWIG IN ORGANIC AND CONVENTIONAL PEACH ORCHARDS

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The omnivorous European earwig, *Forficula auricularia* (L), can serve as a beneficial predator or a phytophagous pest in agro-ecosystems. In peach orchards, earwigs may feed on and regulate populations of pest insects such as the green peach aphid and peach twig borer; however, they also feed on ripening fruits and young leaves causing crop injury. Organic and sustainable peach producers have requested non-chemical alternatives for earwig management. The goal of this study was to elucidate the factors that affect earwig-peach orchard interactions, such as feeding behaviors and phenology.

Earwigs were sampled from five peach orchards in Utah (Davis and Utah Counties) with cardboard roll traps to characterize earwig phenology and population density. There were no differences in capture betweentrunk- and canopy-placed traps. Adults capture began12 March and first generation nymphs in their 2nd instar by 25 March.Peak nymph catch, dominated by 3rd and 4th instars, occurred in late June. First-instar and young, 2nd-instar nymphs remain inthe nest (sitters),thereforetrapping data of these two stages was incomplete. Using a lower developmental threshold (baseline) of 6.5°Cand a start date of 1 January we developed a degree-day (DD) model (single-triangle) for Utah earwigs. We found that overwintered adult emergence peaked at approximately 250 DD.Mobile, 2nd-instar nymphcatchpeaked at300 DD. At425 DD, trap catch was composed of fifty-percent2nd and3rd-instar catch. Fifty-percentfourth-instar catch occurred at500 DD and at775 DD for F_1adults.A laboratory colony was established to monitor the development rate of F_1 generation earwigs. At constant 20 °C,earwigs required 50 DD more than those in the field from egg to adult. Inadequate nutrition was the likely cause of the slower development rate.

In orchards, we found that earwig functional-roles depended largely on their phenology, as well as the phenology of their food source. Peach tree feeding injury by nymphs was not observed. Overwintered adults began feeding on peachleaves by first bloom, and 13% of leaves showed signs of injury in early July. Fruit-feeding began at ripening inmid-August. The firmness of fruit-flesh significantly differed for damaged and intact peaches (1-tailed t-test, $p = 0.02$) and damaged area was negatively correlatedto firmness ($r = -0.66$, $r^2 = 0.44$). Earwig feeding was nocturnal with peak activity at 2200H. Uncontrolled earwig feeding was capable of inflicting significantfruit loss, up to45%of fruitsunsaleable.The estimated economic loss for these orchards, 2nd and 3rd yearStellar/Lovell peaches planted with 8’ x 16’ spacing, was $38/acre wholesale or $60/acre retail. These results emphasize the importance of timelinessfor management decisions.

MATING DISRUPTION OF LIGHT BROWN APPLE MOTH IN CALIFORNIA STRAWBERRIES

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The light brown apple moth (LBAM), *Epiphyas postvittana* Walker (Lepidoptera: Tortricidae), is an introduced leafroller pest in California, currently subject to intra- and inter-state quarantines. We evaluated the efficacy of Isomate® LBAM Plus (Pacific Biocontrol Corporation, Vancouver, WA) mating disruption dispensers in central coast California strawberry fields. The product was applied at approx. 56 g of active ingredient (400 dispensers) per acre on 8-acre organic

strawberry field plots. Treatment plots were site-paired with untreated control plots of equal size (N=4). Male *E. postvittana* trap capture was monitored using 12 orange large plastic delta (LPD) pheromone traps (Suterra, LLC) per plot for 14 weeks following treatment applications commencing June 15, 2010. Male LBAM trap capture was significantly reduced on treated plots for the duration of the experiment. Overall, the results suggest that ground-applied mating disruption may be a useful tool to include in integrated pest management of *E. postvittana* in California agriculture.

OUTREACH TO PRESERVE PHEROMONE MATING DISRUPTION PROGRAMS IN OREGON AND CALIFORNIA PEAR ORCHARDS

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Commercial pear growers in Jackson County, OR and Lake County, CA have been leaders in adopting integrated pest management (IPM) approaches in their orchards, such as the use of pheromone mediated mating disruption for control of codling moth. These IPM programs have resulted in reduced pesticide use in commercial orchards and cost savings for pear producers. However, ongoing infestation of insect pests and diseases from nearby unmanaged trees forces commercial growers to use more pesticides, threatening the environment and reducing profitability. The purpose of the Unmanaged Apple and Pear Tree Outreach Program—UAPTOP—is to educate the public about the importance of reducing the number of unmanaged pear and apple trees within 1/4 mile of commercial pear orchards. Outreach methods include newspaper articles, annual gardening calendar, information booths at public events and farmers' markets staffed by Master Gardeners, and cooperation with local nurseries. Target trees are located using GPS and mapped on an interactive website developed in collaboration with UC Kearney Agricultural Center GIS Center. Program effectiveness is measured by documenting the number of unmanaged trees before and at the end of the program, as well as surveying consumers of project information on the usefulness of our products and whether they have changed their behavior.

MANAGEMENT OF LITTLE FIRE ANTS (*WASMANNIA AUROPUNCTATA*) IN THE PACIFIC

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Over the last century or so, the Little Fire Ant has spread throughout tropical regions worldwide. Pacific islands offer near-ideal conditions for this species to survive and thrive. The combination of year-round warm weather, abundant rainfall, a plentiful supply of canopy cover, a lack of biotic resistance, and the relative low capacity in Pacific islands for detection, response and management of incursions are the most likely reasons for its success in this region. The impacts

of this species are wide ranging and include reductions of forest biological diversity, reduced plant health and a lower quality of life for people, especially those engaged in subsistence lifestyles.

Little Fire Ants have proven almost impossible to eradicate and even control efforts are often unsuccessful. This is due in large part to its habit of nesting both within the ground layer and canopies of forest habitats. Conventional ant baits are mostly manufactured for deployment on the ground layer and this results in the survival of arboreal colonies, which eventually recolonize ground habitats.

We report here on the impacts of Little Fire Ants across the Pacific, the failures and successes of various control methods and development of novel approaches to the limitations of conventional baits against this species.

MANAGEMENT OF SPOTTED WING DROSOPHILA IN SWEET CHERRIES

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Spotted Wing Drosophila (SWD) has recently become a significant pest of sweet cherry in the Western United States. Control has relied on repeated applications of insecticides. However, little information concerning the relative efficacy of registered insecticides on SWD in cherry is available. Thus research was initiated to investigate the relative efficacy of registered insecticides on sweet cherry for SWD control and on the proper time to initiate seasonal control programs. In the first series of studies, most registered insecticides on sweet cherry were applied to single-tree replicates using an air-blast sprayer and hand-held orchard sprayer. There were four replicates per treatment. Since treatments were applied post-harvest or to orchards without SWD populations, the treated fruit and foliage were returned to the laboratory at various times after treatment and exposed to laboratory rear flies. Adult male and female SWD were placed on the treated foliage for 24 hours and mortality was reported. Also, adult male and female SWD were placed on the treated fruit for 24 hours and allowed to oviposit. Adult mortality, the number of eggs oviposited and resulting F1 adult was recorded. These studies show that organophosphates provided good knock down control and 3 to 7 day residue control, spinosyns provided moderate knock down control and 3 to 7 day residue control, pyrethroids provided moderate knock down control and 7 to 14 day residue control and the neonicotinoids provided little adult control. However, the neonicotinoids appear to provide ovicide/larvicide control. Control program initiation studies were conducted where insecticide applications were initiated at various days after full bloom (DAFB). SWD adults were monitored weekly through the season with apple cider vinegar traps and the fruit infestation was determined from four weeks before to four weeks after commercial harvest. Initiation of control at 14 DAFB or green colored

fruit, 46 DAFB straw colored fruit and at 52 DAFT or pink colored fruit did not result in infested fruit at harvest or post-harvest. However, initiation of control at 59 DAFB or red colored fruit and the untreated check provided significant SWD infestation two weeks after harvest. Phytotoxicity of ground applied Malathion and the efficacy of aerially applied Malathion will be discussed.

MONITORING AND CONTROL OF EUROPEAN GRAPEVINE MOTH, *LOBESIA BOTRANA* (LEPIDOPTERA: TORTRICIDAE) IN CALIFORNIA VINEYARDS

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Lobesia botrana (Denis & Schiffermüller), European grapevine moth, was found in mid-September of 2009 for the first time in the United States in vineyards in California. This moth belongs to the family Tortricidae, sub-family Olethreutinae. The initial find and the highest populations were detected in Napa County. It has since been found in Fresno, Mendocino, Merced, Monterrey, San Joaquin, Santa Clara, Santa Cruz, Solano and Sonoma counties, although at much lower densities and with very limited geographic distribution.

During the 2010 season we compared commercial available *Lobesia botrana* lures to monitor populations with traps. Rubber septa lures caught significantly more moths early in the season (March), while membrane lures caught significantly more moths on some dates during late spring and summer. Insecticide efficacy trials were conducted against first- and second-generation larvae. In a trial targeting the former, one application of methoxyfenozide gave the best control and the other three treatments (three applications of *Bacillus thuringiensis*, one application of chlorantraniliprole, and two applications of the organic formulation of spinosad) were equally effective giving adequate control. In a trial targeting mature larvae, abamectin, indoxacarb and spinetoram gave the best control followed by chlorantraniliprole.

THE COFFEE BERRY BORER: AN OVERVIEW

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The genus *Coffea* (Rubiaceae) comprises 103 species, but only two of these are commercially traded: *C. arabica* and *C. canephora* (also known as robusta). Coffee is grown in more than 10 million hectares in over 80 developing countries and ca. 20 million families depend on this plant for their subsistence. Among the hundreds of insect that attack coffee, the coffee berry borer, *Hypothenemus hampei* (Coleoptera: Curculionidae: Scolytinae), is considered to be the most important throughout the world. Adult females bore a hole in the coffee berry, where they deposit their eggs; upon hatching, larvae feed on the coffee seeds inside the berry, thus reducing yield and quality of the marketable product. The insect spends most of its life inside the coffee

berry, making it extremely difficult to control. Various biological control agents have been reported as natural enemies of the coffee berry borer, including parasitoids, predators, nematodes, and fungal entomopathogens. A novel strategy based on the use of fungal entomopathogens as fungal endophytes was recently attempted. Even though ants and birds have been reported to prey on the insect, they are not considered important mortality factors. Jaramillo et al. (2010) reported on the black thrips, *Karnyothrips flavipes* (Phlaeothripidae), as a predator of egg and larvae of the coffee berry borer in Kenya. The thrips has been reported in Hawaii. The specific cues used by the coffee berry borer to localize the berry have not been elucidated; their identification could be a great improvement over the current use of the ethanol:methanol attractants.

ALKALI BEE FLIGHT MONITORING WITH VEHICULAR BEE SWEEPER IN WASHINGTON STATE

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Pollination by the alkali bee (*Nomia melanderi*) is essential for seed set in alfalfa seed production. *N. melanderi* is a solitary ground-nesting bee that aggregates in sub-irrigated salt flats. The Washington State Department of Transportation is proposing an upgrade of US Highway 12 that will pass through the Lowden-Touchet-Gardena seed growing district of southeastern Washington State. Speed limits are posted on county roads located near alkali bee beds and the proposed four-lane highway could pose a negative impact to the bees and seed yield in the area due to bee mortality from motor vehicular traffic. In order to mitigate the effects of traffic on *N. melanderi*, we established methods to assess alkali bee flight height and behavior. We constructed a 'vehicular bee sweeper' designed to capture insects at specific heights over county roads. This bee sweeper device involved sweep nets attached to a moving vehicle. We pooled our samples for each height and determined the majority of *N. melanderi* flew at heights below 2.1 meters when no other factors (location, temperature and wind speed) were considered. We found differences in bee abundance per location. Environmental conditions such as temperature and wind speed had an effect on *N. melanderi* as well. *N. melanderi* flies at lower heights when the temperature is below 32.2°C than it does when the temperature is above 32.2°C. No alkali bees were found over 2.1 meters when wind speeds exceeded 6.46 kilometers per hour, but were evenly distributed among all heights when wind speed remained below 3.2 kilometers per hour. Location, temperature and wind speed had an effect on bee flight height and behavior. This study will be repeated in 2011 with higher height assessment. By determining *N. melanderi* flight height and behavior, we can attempt to minimize the impacts of vehicular traffic from the new highway.

HONEY BEE SWARMS' GROUP DECISION-MAKING INVOLVES CROSS INHIBITION SIGNALS, SIMILAR TO VERTEBRATE-BRAIN DECISION-MAKING.

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Honey bee swarms make decisions between alternative nestsites by a competitive process: the first site whose scouts attract a large enough "quorum" of others visiting the site is selected. This process relies on positive feedback through recruitment dances. We found that a negative-feedback signal is also involved. Bees which have visited a site (and been distinctively marked) sometimes deliver short vibratory "stop signal" beeps to dancers. We found that most of the signals received by a bee dancing for a particular site come not from bees that also visited that site, but from scouts marked at other sites–it is cross inhibition. This mirrors the neurobiological underpinnings of decision-making in vertebrate brains: Neural centers accumulate activity for alternatives, and lead to a decision when a threshold of activity is reached, but also actively inhibit other centers. Models suggest this optimizes decision-making and ensures that just one alternative is chosen. Decision-making in bee swarms and brains have apparently converged on the same mechanism. When a quorum is reached at the nestsite, the stop signal beeps are again used, now apparently to shut off recruitment so that most bees will be present when the swarm flies to the chosen site. In this phase, scouts beep dancers both for their own site and other sites. When just a single site is discovered, with no scouts for alternative sites to deliver cross-inhibition, very little stop signal is delivered to dancers prior to the decision point, but it does occur in the post-decision phase.

IMPLEMENTATION OF DATABASE MANAGEMENT AND ANALYSIS PIPELINE FOR ORIENTAL FRUITFLY GENOMICS RESEARCH

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The Pacific Basin Agricultural Research Center (PBARC) of the USDA Agricultural Research Service (ARS) is leading research into the genomics of the oriental fruit fly (*Bactrocera dorsalis*) and related fruit fly species. Efforts include whole genome shotgun sequencing, deep transcriptome sequencing throughout the life history of the fly, and a reduced representation approach to comparative genome sequencing of related species (RAD-TAG analysis). Results are expected to clarify our understanding of population and species diversity and distribution within this species, as well as host plant-insect interactions to identify potential targets for control strategies. In order to derive insight from the voluminous sequence data being generated, a genomic database and analysis pipeline will be required. After investigating a number of potential options, we are implementing a range of Generic Model Organism Database (GMOD) components. To date, progress has been made in using Chado, Maker, Apollo and GBrowse. In addition, these tools will be supplemented with other utilities as necessary to manage information and to conduct analysis of gene structure, function, evolution, regulation, networks and interactions. During the presentation, plans for the genomic analysis effort will be presented, along with progress to date using examples relevant for genomics researchers and fruit fly biologists.

CROP SUSCEPTIBLY TO SPOTTED WING DROSOPHILA ATTACK

Douglas Walsh[1], Jana Lee[2], Vaughn Walton[3], Lynell Tanigoshi[4], Tom Walters[4], [5]Kim Patten and [6]Frank Zalom

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Evidence indicates that Spotted Wing Drosophila *Drosophila suzukii* (Matsumura) was inadvertently introduced from Asia into California via Hawaii in 2008. Following its introduction into California SWD rapidly expanded its geographic range and began to exploit a diversity of host fruits. The existing literature in English was lacking and there were significant concerns among agricultural producers regarding the relative susceptibilities of specific crops to infestation by SWD. In response, University and USDA entomologists have initiated preliminary studies to evaluate the specific properties required in fruits for successful colonization by SWD. Several Pacific Coast fruit crops were well documented hosts for SWD. These include grapes, caneberries, and cherries. Other fruits were novel associations not previously in the literature. These include cranberries and Italian plums. The preliminary results from bioassays to determine the susceptibilities of these fruits to SWD infestation will be discussed.

LYGUS CONTROL IN ALFALFA PRODUCED FOR SEED: KILLING THE BUGS WITHOUT KILLING THE BUZZ

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[1]Washington State University and [2]University of Idaho

Economic control of Lygus bug (*Lygus hesperus* Knight) in Western US alfalfa seed fields relies on insecticide applications based on grower routine. The phenological onset of flower bloom and the introduction of pollinating bees into the agroecosytem complicate matters. Unfortunately these cycles are often in synchrony with the early-summer nymphal-hatch of the first of several annual Lygus generations. Synthetic pyrethroid and organophosphate insecticides are applied as nuclear "clean-up" sprays prior to the onset of bloom. Obviously, there are negative consequences associated with the application of these broad-spectrum insecticides including the disruption of the beneficial arthropod populations and the flaring of spider mite populations. Following these clean-up sprays, one to several species of pollinators are added into the system. These pollinators include the alfalfa leafcutting bee *Megachile rotundata*, alkali bee *Nomia melanderi*, or the honey bee *Apis mellifera.* Applications of insecticides for Lygus control during these critical bloom periods must be made with great care and consideration to avoid harm to these costly and important pollinators. Until 2007, the predominant insecticide applied to alfalfa seed feeds during bloom was naled. Several insecticides have been registered since 2006. These include the insecticides acetamiprid, novaluron, and flonicamid. Use varies geographically. Idaho producers have adopted the use of novoluron, while Washington growers have come to adopt the use of flonicamid. Some will even tank mix flonicamid or novaluron with naled for that extra kick. Most of these insecticide applications are applied in the early evening to avoid exposure to pollinators. After bloom is completed some growers choose to apply an additional set of broad-spectrum insecticides as a final clean up spray prior to seed harvest.

A complex of braconid parasitoids (*Peristenus* spp.) have been observed in alfalfa seed fields. In an undisturbed alfalfa seed field on the University of Idaho, Parma campus parasitism rates of 100% have been in observed in Lygus populations. The greatest rate of parasitism observed in commercial fields to date was approximately 30%. Unfortunately the commercial applications of insecticides and other farming practices appear to limit the effectiveness of biological control. We will discuss our efforts over the past 10 years to develop a comprehensive integrated insect management program on Lygus and pollinators in the alfalfa produced for seed crop.

NICHINO AMERICA'S TOLFENPYRAD UPDATE

Allison Walston[1]

[1]Nichino America, Inc., The Dalles, OR

This presentation will provide an update on Nichino America's upcoming insecticide, tolfenpyrad.

SPOTTED WING DROSOPHILA OBSERVATIONS IN COMMERCIAL BLUEBERRY AND WINE GRAPES IN THE WILLAMETTE VALLEY OF OREGON

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Spotted Wing Drosophila (SWD, *Drosophila suzukii*) is a pest that directly attacks several small fruit species in Oregon. Our pest monitoring work focused on weekly recordings in three commercial Willamette Valley blueberry fields and five vineyards during 2010. Baited traps were monitored in both crops as well as in surrounding blackberry stands. Fruit collections were additionally made in close proximity to each trap in order to determine larval infestation. Surrounding blackberry trap SWD counts were made for more extended periods during the season than in vineyards and blueberries. Blackberry fruit infestation was found as soon as blackberries started to change color and continued into the fall period. Trap counts in blueberry fields remained low until after the harvest period when the counts increased exponentially. No blueberry fruit infestation was found until after harvest and was located in specific hot spot areas. Several pesticide applications were made in blueberries in both conventional and organic fields. SWD trap counts in wine grapes followed a similar trend to that of blueberries, but trap counts were high approximately two weeks before harvest until several weeks after harvest. No wine grape infestations were found, however, in any sampled fruit in the five selected vineyards despite the high trap counts. Subsequent sampling of fruit in additional vineyards showed

limited SWD larval infestation. Potential host suitability of blueberries, wine grapes and blackberries will be discussed based on trap counts and fruit infestation.

CONTROL OF ONION THRIPS IN DRY BULB ONIONS IN WASHINGTON STATE

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Onion thrips (*Thrips tabaci)* are the key pest of dry bulb onions in Washington State. Our project goals were to: ascertain which thrips species are found on onions in Washington, to determine which registered and new chemistries effectively control thrips, and evaluate different water application gallonage rates and delivery pressures for applying insecticides for thrips control. During 2007-2010 onions (var. Tamara) were established at the WSU Othello Research Farm and grown using standard grower practices. Plots (7.5 feet wide and 30 feet long) were established in a random complete block design with four replications. Efficacy was evaluated by counting the number immature and adult thrips per plant on 10 individual plants per plot in the field. All data for each sample date was analyzed by ANOVA and treatments compared to non-treated controls in pairwise *t*-tests. During all evaluation dates, greater than 95% of the thrips collected were onion thrips (*Thrips tabaci)* with the remaining thrips being Western flower thrips (*Frankliniella occidentalis).* The most effective insecticides for controlling thrips were Lannate (methomyl) and Radiant (spinetoram). The insecticides Agri-Mek (abamectin) and Movento (spirotetremat) provided adequate control of thrips. Different application gallonage and pressure did not affect efficacy of insecticides.

EVALUATING STATEWIDE IMPACT OF WEED BIOLOGICAL CONTROL USING THE STANDARDIZED IMPACT MONITORING PROTOCOL (SIMP)

Aaron Weed and Mark Schwarzländer

University of Idaho, Department of Plant Sciences and Entomology

Long term monitoring of weed biological control programs is essential for evaluating the effectiveness of released agents. Traditionally, biological control monitoring has been conducted over relatively short time periods and within restricted geographical areas. These approaches help in assessing local agent impact, but do not assess long-term dynamics of the weed-agent interaction under shifting environmental conditions. Understanding factors affecting variation in agent efficacy across a landscape is arguably one of the most important aspects of post-release biocontrol evaluation and future implementation. The Standardized Impact Monitoring Protocol (SIMP) was developed as a user-friendly protocol to address these concerns. SIMP provides a relatively fast assessment of agent and weed abundance and plant community composition that is attractive to land mangers and easily implemented over large regions. Currently, SIMP has been applied to assess the impact of biological control against 7 weeds in Idaho. This presentation will summarize results generated by SIMP from selected biological control systems to highlight the strengths and challenges of implementing this monitoring protocol.

SPATIAL DYNAMICS OF DALMATIAN TOADFLAX (*LINARIA DALMATICA*) AND THE STEM-MINING WEEVIL *MECINUS JANTHINUS* IN THE NORTHWESTERN UNITED STATES

Aaron Weed and Mark Schwarzländer

University of Idaho, Department of Plant Sciences and Entomology

The stem-mining weevil *Mecinus janthinus* Germar was introduced into North America in the mid 1990s as a biological control agent of the herbaceous perennial Dalmatian toadflax (*Linaria dalmatica* (L.) P. Mill.) Studies have demonstrated reductions in stem density and reproduction in areas where the weevil was released, but it is unclear whether weevil attack affects the spatial distribution and demography of Dalmatian toadflax populations. These alterations to the toadflax population may in turn affect host-finding ability, population growth, and effectiveness of *M. janthinus*. This study was initiated to evaluate the spatio-temporal dynamics of Dalmatian toadflax biological control in the Northwestern US. We observed substantial population-level variation in toadflax and weevil abundance among four widely distributed sites. Despite these differences in stem density, *M. janthinus* effectively tracked the spatial structure of Dalmatian toadflax stem density at each site. The Spatial Analysis by Distance IndicEs (SADIE) methodology indicated moderate clustering of Dalmatian toadflax. Weevil activity was generally aggregated in areas of high stem density in all sites. Future sampling will be conducted at these sites to continue evaluating the spatial dynamics of Dalmatian toadflax biological control.

INSECT PEST RESPONSE TO CONSERVATION TILLAGE IN SUGAR BEETS

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Strip tillage, a form of conservation tillage in which tillage is reduced to a narrow band where the seed and fertilizer are placed, saves grower time and fuel expenses and can mitigate a number of soil-related production problems in sugar beets. Although reduced soil disturbance associated with conservation tillage is expected to favor certain insect pests, little experimental evidence exists on effects of tillage on insects in sugar beets. We conducted the first year of a multi-year field study in which strip tillage is being compared with conventional tillage. Pressure was minimal from insect pests that are expected to be more directly affected by tillage, including cutworms and wireworms; however, abundance of beet leafminer flies and bean aphids was either similar between tillage types or higher under conventional tillage. Yields also were similar between tillage types. Although there was limited pressure from soil-dwelling pests, the results presented here suggest that strip tillage in sugar beets may contribute to a reduction of certain pests. The potential mechanisms involved will be discussed.

EATING FLIES: PARASITOIDS OF TEPHRITIDAE AND DROSOPHILIDAE

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The parasitoids of Tephritidae and Drosophilidae are reviewed briefly. There are very few species that successfully attack both tephritids and drosophilids, despite the co-occurrence of these hosts in some substrates. The evolution of tephritid parasitism is discussed, with emphasis on the eucoiline Figitidae and Braconidae. Hypotheses are presented for transitions from saprophagy and herbivory to frugivory. Within the braconid sister-groups Opiinae and Alysiinae, drosophilid parasitism is rare in Opiinae and tephritid parasitism is rare in Alysiinae. Drosophilid parasitoids, particularly in the genus *Asobara*, are diverse in the tropical eastern Pacific Region but appear to be absent in Hawaii. This suggests that the mega-diverse Hawaiian Drosophilidae have left one of their natural enemies behind. A less likely alternative hypothesis is that sampling for drosophilid parasitoids in Hawaii has been inadequate. Some opiine parasitoids show interesting patterns of host relationships that pose challenges for predicting host suitability of related target pests.

THE COMPLICATED NATURE OF USING NATIVE SPECIES FOR BIOCONTROL

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The use of different organisms for biological control is not a new concept to the field of Entomology, but what is a more novel idea is trying to use native organisms for the same purposes. One of the most famous cases touting the success of biological control has been the worldwide introduction and use of Mosquitofish, *Gambusia affinis* and *Gambusia holbrooki* for the control of larval mosquitoes in efforts to prevent the spread of arboviruses to humans. However, a variety of negative impacts have now been attributed to *Gambusia* in systems in which they were introduced. The use of organisms already native to a given ecosystem for the purposes of biological control and overall novel IPM strategies are now beginning to be more widely explored.

ECOLOGICAL EFFECTS OF *VESPULA PENSYLVANICA* ON HAWAIIAN ARTHROPODS

Erin E. Wilson

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Introduced species may disrupt ecosystems to the greatest extent when strong disparities exist between the biotas of recipient and donor regions. The Hawaiian archipelago is of particular interest in that continental invaders to this region often fundamentally differ from endemic taxa. Social Hymenoptera, for example, may be especially problematic invaders given that the

ecological roles that social Hymenoptera typically fill in continental ecosystems (e.g., pollinators, predators, scavengers) are performed by a few genera of solitary Hymenoptera. Replacement of native solitary Hymenoptera with social introduced forms thus gives rise to qualitative and quantitative changes in the composition of hymenopteran assemblages and in the ecosystem services provided by this important insect order. The invasion of a social scavenging predator, the western yellowjacket (*Vespula pensylvanica*), affects native Hawaiian arthropods on multiple trophic levels. Yellowjackets reorganize native assemblages through predation and competition. These interactions result in the displacement of native taxa in areas with high yellowjacket densities. Furthermore, yellowjackets are subsidized by another introduced social insect, the European honeybee. Honeybees provide yellowjackets with reliable sources of protein and carbohydrates – a trophic subsidy that may be particularly important for yellowjackets during periods of seasonal prey and nectar scarcity. The ecological effects of honeybee resources increase the capacity of yellowjackets to prey on and compete with native taxa.

NEALTA™: A NOVEL BASF ACARICIDE FOR CROP PROTECTION

Tommy Wofford and Venkat Pedibhotla

BASF Corporation, 26 Davis Drive, Research triangle Park, NC 27709

Nealta™ is a new and novel miticide to the US crop protection market. The active ingredient belongs to the acrylonitrile class of chemistry, which exhibits strong activity against phytophagous mites. Nealta is a 20% SC formulation containing the active ingredient Cyflumetofen. Nealta™ is a contact miticide and is effective on all mite life stages. Its residual activity is as strong as or better than today's market leading miticides. While the mode of action is currently under investigation, it has not shown cross-resistance to any known miticides. Because cyflumetofen is primarily active against tetranychids, it has low toxicity towards non-target organisms including beneficial mites which help make it an excellent fit in an overall IPM program. BASF plans to launch this product into the tree nut, tree fruit, grape, tomato, strawberry and ornamental markets by 2014.

ANALYSIS OF FACTORS ASSOCIATED WITH SUCCESSFUL ESTABLISHMENT OF HYMENOPTERA INTRODUCED TO HAWAII AS BIOLOGICAL CONTROL AGENTS

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Successful establishment of biological control agents is a fundamental step in effective classical biological control of invasive pest species. Climatic suitability of recipient environments for new introductions has received considerable attention, but there are still gaps in our understanding of the biotic factors that may play a role. Variables such as presence of closely related species, diversity of pests within host range, host range, and utilization of indigenous non-target hosts have received limited attention. Here we analyze data on introduction and establishment successes and failures of parasitic Hymenoptera introduced to Hawaii, with special reference to Darwin's Naturalization Hypothesis, facilitation and parasitoid host range. The presence of

'other pest species' within the realized host range of introduced Hymenoptera contributed substantially to establishment success, suggesting that facilitation plays an important role.

TRAPPING IN COFFEE BERRY BORER MANAGEMENT

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Research on the use of trapping systems and different attractants in coffee berry borer (*Hypothenemus hampei*) management is reviewed. Methanol / ethanol mixes are the most effective attractants, compared with kairomone sources such as coffee berries, ground green coffee and caffeine. In South America, minimal numbers of coffee berry borer are trapped outside of coffee plantations. Trap type, trap placement and beetle phenology have investigated. It suggested that 22 traps per hectare would provide effective mass trapping in coffee plantations in Colombia. Some researchers propose that stringent sanitation combined with mass trapping can reduce coffee berry borer losses by 90%.

FIELD EVALUATION OF INSECTICIDES FOR MANAGING GILL'S MEALYBUG (*FERRISIA GILLI*) IN VINEYARDS.

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Gill's mealybug, *Ferrisia gilli* (Gullan), has been a noted pest of pistachio and almonds in California since the 1990's and was, surprisingly, first found on grapes grown in El Dorado County, California, in 2004. Since that time, it has spread throughout vineyards in the area, infesting approximately 350 acres to date. Gill's mealybug found in clusters at harvest are undesirable, decreasing the yield and potential value of the crop. We evaluated the insecticides acetamiprid (Assail 70WP, Cerexagri-Nisso LLC), buprofezin (Applaud 70DF, Nichino America Inc.) and clothianidin (Clutch 50WDG, Valent Corp.), compared to an untreated control, for Gill's mealybug management in a commercial Merlot vineyard during the 2010 season. Insecticides were applied twice at a 2 week interval with an airblast sprayer in a randomized complete block design with five replicates, targeting the crawler stage of Gill's. Leaf counts of crawlers and whole vine ratings were conducted during the season. Prior to harvest, 300 clusters per treatment were rated on a scale of 0-3, where "0" indicates no damage or mealybugs visible when clusters are examined, "1" indicates 1-5 mealybugs, "2" indicates 6-15 mealybugs, and "3" indicates more than 15 mealybugs, unmarketable fruit. Results from that evaluation showed that all treatments gave greater control than the untreated. In the untreated, 46% of the clusters evaluated were rated a "0" , 23% were rated a "1", 14% were rated a "2", and 17% were rated a "3". The acetamiprid treatment provided the greatest control (97% of the clusters were rated a "0"), followed by the buprofezin treatment (92% rated "0"), and the clothianidin (83% rated "0").

CRUMBLING FOUNDATIONS? COULD CLIMATE CHANGE AND LANDSCAPE SIMPLIFICATION JOINTLY AGGRAVATE THE INVASIVE SPECIES PROBLEM IN SOUTH AMERICA?

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Invasive species affect local ecosystems in many ways, impacting biodiversity, compromising human health or interfering with agricultural production. In South America, a broad literature revision documented >300 exotic arthropod species. For each species, potential impact was assessed through determining geographic distribution, association with key commodities and eventual documented (agricultural) yield impacts or biodiversity losses. Spatial distribution of the ten most worrisome species was modeled based upon climatic data, through MAXENT. For many of the species, regions of climatic suitability were far larger than previously expected and commonly expanded under (projected) climate change scenarios. For a given species, lack of observation records from certain suitable regions, such as the Amazon basin, could possibly indicate an increased resilience of those areas thanks to diversified landscapes or high biodiversity. The effect of landscape diversification is exemplified through ever more severe outbreaks of the exotic coffee berry borer *Hypothenemus hampei* in Colombian coffee production landscapes, which have become subject to drastic modification during the past decade. Our work could help define contingency and management plans for invasive arthropods, which likely should include intervention at the landscape level.

POST RELEASE EVALUATION OF THE IMPACTS OF THE EURYTOMID PARASITOID ON ERYTHRINA GALL WASP AND THE NATIVE WILIWILI

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The invasion of the Erythrina Gall Wasp (EGW), *Quadrastichus erythrinae* (Kim) in 2004 threatened the existence of *E. sandwicensis* in Hawaii. Five years of unrelenting damage by EGW on Erythrina species had stake holders, scientists and researchers in Hawaii striving for tactics to save the native species *E. sandwicensis*. A promising bio-control agent was collected in Tanzania and underwent rigorous risk assessment at the Hawaii Department of Agriculture insect containment facility. In November 2008, *Eurytoma erythrinae* (Gates & Delvare) was approved to be released into the environment to control EGW. Pre and post-release evaluations were initiated to evaluate the impacts of the Eurytomid parasitoid on the gall wasp and the Erythrina trees. Regular sampling and gall dissections showed that the parasitoid became established within 6 months of its release. Results from post-release monitoring indicate that *E. erythrinae* is successfully controlling gall wasp populations at most sites, and surviving wiliwili

trees are recovering from gall wasp damage. Post release monitoring continues in order to determine the impact that *E. erythrinae* will have on the species' long-term viability.

TERMIDOR®DRY: A NOVEL INSECTICIDE FORMULATION FOR SPOT TREATMENT OF DRYWOOD AND SUBTERRANEAN TERMITE INFESTATIONS

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Tools for managing drywood termite infestations for many decades were limited to fumigation and insecticide spot treatments. These were followed by non-chemical methods such as treatments with heat, low temperatures, electricity and microwaves. A recent introduction to the spot treatment regime is a non-repellent phenyl pyrazole insecticide better known as Termidor. The new Termidor Dry formulation is composed of micro cellulose particles (Microllose^{TM}) impregnated with 0.5% Termidor. Particle size ranges from ~20-100 microns, hardly visible to the naked eye. Microllose acts as a carrier of Termidor and as an alternate diet component. Initial laboratory observations indicate good adhesion of the particles to treated substrate surfaces, as well as the integument of the target pest, and lateral transfer among nest mates of *Cyptotermes brevis* and *Coptotermes formosanus*. Major mortality for both species occurred within 24 hours.

SUBTROPICAL FRUIT FLY INVASIONS INTO TEMPERATE FRUIT FLY TERRITORY IN CALIFORNIA'S SAN JOAQUIN VALLEY

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Subtropical fruit fly species including peach fruit fly, *Bactrocera zonata* (Saunders); melon fly, *B. cucurbitae* (Coquillett); oriental fruit fly, *B. dorsalis* (Hendel); and Mediterranean fruit fly, *Ceratitis capitata* Weidemann, have been detected in the past decade in the San Joaquin Valley of California. This southern part of the Central Valley is the primary agricultural production region for the state and considered a world breadbasket. A temperate climate fruit fly, walnut husk fly, *Rhagoletis completa* (Cresson) is established in walnuts in the San Joaquin Valley. A Mediterranean climate fruit fly, olive fruit fly, *B. oleae* (Rossi) was first found in 1998, and became established in olives but in low numbers. The biology of these species allowed them to survive the hot, arid summers and cold winters. The occurrence of a diversity of subtropical fruit flies in the past few years and their failure to establish is discussed in relation to their biology and host availability. The detection of exotic fruit flies in areas where they have never occurred is presented in relation to the geography and sociology of the region.

RELEASING THE OLIVE FRUIT FLY'S NEWEST ENEMY, *PSYTTALIA HUMILIS,* IN THE FIELD

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The olive fruit fly (*Bactrocera oleae*) threatens California's olive industry. First discovered in Los Angeles, California in 1998, the olive fruit fly quickly spread throughout the state. In 1999, olive fruit fly was found in several counties. It infests the olives of ornamental and commercial olive varieties. Once the fly has found its host, it lays its eggs forming larvae which viciously consume the olive pulp. The larvae pupate and emerged leaving behind shriveled, spotted, and discolored fruit. Recently, a small parsitioid (*Psyttalia humilis*) from Northern and Sub-sahran Africa was approved for release in California. In previous studies, *P. humilis* was transported and released in framed aluminum cages at release sites. Water and honey is placed in the cage to promote survival. In the field, parasitoids are released by opening the lid of the cage. However, the parasitoids are not eager to leave the cage. As a result, the cages are secured to the tree and left overnight to allow the parasitoids more time to disperse. When the cages are taken down from the tree, there are still many parasitoids that remain. Many remain in the cage to feed on the remaining water and honey placed in their cage for transport, making the cage a more tantalizing host over the olive. Therefore, new release techniques must be designed in order to improve the efficacy and success of parasitoid release.

SULFOXAFLOR: A NEW SAP-FEEDING INSECTICIDE

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Sulfoxaflor is a new broad spectrum insecticide under development by Dow AgroSciences. It is a member of a new chemical class of insecticides called sulfoximines and is active on aphids, plant bugs, whiteflies, planthoppers, scales and other sap feeding pests. Field trials have demonstrated rapid knockdown and extended residual control of key pests of tree, vine and row crops. Sulfoxaflor has not exhibited cross resistance to insect strains resistant to neonicotinoids and other classes of insecticides. Favorable environmental and toxicological profiles make sulfoxaflor an excellent option for IPM and resistance management programs.

INSECTICIDAL IMPLICATIONS ON THE NATIVE PREDACIOUS MITE, *EUSEIUS HIBISCI* (ACARI: PHYTOSEIIDAE) IN SOUTHERN CALIFORNIA AVOCADOS.

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Avocado thrips, *Scirtothrips perseae* Nakahara, was first reported in 1996 damaging foliage and fruit of Hass avocados. Avocado thrips feeding can scar the entire fruit surface leading to economic losses as fruit are culled or downgraded. As thrips pressure increases in southern California avocados, insecticide use may also increase. The native predaceous mite, *Euseius hibisci* is particularly common in avocado orchards and is considered a significant generalist predator. *Euseius hibisci* is capable of building to high densities in the absence of mite prey and can successfully survive and reproduce on a diet of pollen among other food sources. We evaluated four insecticides currently registered for southern California avocados; Agri-Mek (abamectin), Danitol (fenpropathrin), Delegate (spinetoram), Veratran-D (sabadilla) and a control (water) against *E. hibisci* using a dilution rate of 300 gpa. Individual leaves were flagged, treated, and allowed to weather in the field on the tree until used in laboratory bioassays at various times post insecticide application (1, 3, 7, 14, 21, etc, days). Bioassay mortality readings were taken 1 - 5 days post bioassay setup. Each insecticide evaluated caused mortality to *E. hibisci*, with Danitol causing mortality for the longest period of time post treatment (111 d), Agri-Mek caused mortality for the shortest period of time post treatment (7 d). As a separate trial, treated leaves were also exposed to intense ultraviolet light to determine how leaf surface residue would be effected as well as an additional bioassay to determine if mites could detect insecticidal residues on the leaf surface. These results will be discussed further.

ADVANCEMENT OF MOLECULAR METHODS IN IPM

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Molecular biology is a vast area of research with a great number of very useful techniques to aid in advanced, early detection and identification of pests and pathogens, which are the upmost importance in any agricultural context. The basic principles of detection applied to IPM of plant and animal pests and diseases will be discussed including gene expression, biochemical pathways, immunodetection, monoclonal antibodies, DNA-based detection procedures. Sequencing technology is greatly progressing with cost-per-read rates frequently decreasing, resulting in molecular tools that are more cost and time effective. These new technologies are often simple to learn and can be taught to basic level scientists. For example, new multiplexing PCR techniques allow for simple and fast diagnostic capabilities in distinguishing between closely related species or individuals in species complexes. Interestingly, the sterile insect technique using genetically modified strains is currently being tested and marketed both agricultural and human health pests. New insect and plant genomes are being sequenced at incredible rates, providing vast databases of genetic information that have never before been available. In conclusion, it is vital that individuals creating IPM programs understand and utilize the molecular tools currently available in order to create cost effective and cutting edge programs.

IDENTIFICATION OF LYGUS BUGS BY DNA BARCODING FOR IPM

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A complex of *Lygus* bugs species that is dominated by *Lygus hesperus* Knight (Heteroptera: Miridae) is the key direct pest in a broad range of crops in the Western United States. Cropping systems adversely impacted by *Lygus* feeding include alfalfa seed, conifer nurseries, pulse crops, and strawberries. In order to fully implement Integrated Pest Management tactics in the diversity of agroecosystems it is necessary to accurately identify the pest. Although *L. hesperus* is the presumed dominant species, there are several other species of Mirids in the west. In addition, there is evidence that substantial differences exist among closely related species in their host plant preference, susceptibilities to insecticides, intensity of parasitism by specific parasitoids, and level of predation from a complex of generalist predatory beneficial insects within and among regional cropping systems. We are using DNA barcoding to identify cryptic *Lygus*species on different crops in California, and alfalfa in Washington, and Idaho. We have sequenced 452 bp of the mitochondrial cytochrome oxidase 1 gene from 136 *Lygus* from each of these locations. This has provided evidence of haplotype differentiation and phylogenetic relationships of the bugs in this study, showing that the dominant species in Western United States is *Lygus hesperus*. These results are the first step in a comprehensive genetic analysis of *Lygus* bug in the Western United States that will allow us to accurately predict gene flow and species relationships for our future efforts in implementation of IPM strategies.