ABSTRACTS
from the
2010 PACIFIC BRANCH ENTOMOLOGICAL SOCIETY OF AMERICA MEETING

APRIL 11-14, 2010
BOISE, IDAHO, U.S.A.

CONTACTS:

Douglas B. Walsh, 2009-2010 PBESA Branch President
dwalsh@wsu.edu

Sally D. O'Neal, 2010 PBESA Meeting Program Chair
soneal@wsu.edu

SECTION I: PAPER PRESENTATIONS

SYMPOSIUM: SPOTTED WING DROSOPHILA IN THE PACIFIC STATES

1
INSECTICIDE MANAGEMENT OF THE SPOTTED WING DROSOPHILA ON SMALL FRUITS IN WASHINGTON

Lynell Tanigoshi[1] and Doug Walsh[2]
Department of Entomology
[1]Mount Vernon Northwestern Washington Research and Extension Center
Mount Vernon, WA 982273
[2]Irrigated Agriculture Research and Extension Center
Prosser, WA 98350

Drosophila suzukii (Matsumura) (SWD) 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. Processors will reject maggot infested juice grapes, caneberries and blueberries. Consumer appeal towards other fruits including caneberries, blueberries, and cherries will be reduced if fruit is maggot infested. Wine grape quality may suffer from infestation and wine makers will react negatively. Chemical controls for SWD in Washington State cropping systems are in development due to the recent invasion of the pest in late season 2009. It was detected in strawberry and red raspberry in mid-August at the WSU Puyallup REC and since that time, found infesting blueberry, raspberry, blackberry, strawberry and wild blackberry in northwestern Washington. With a rapid generation time, a lengthy list of alternative host fruits, and the fruiting season falling well within the anticipated active period of *D. suzukii*, Pacific Northwest small fruit growers could experience widespread reduction in yield by this potential key pest in 2010. The $210 million dollar small fruit industry in the Pacific Northwest could suffer devastating losses in the coming 2010 season without early intervention. How well SWD will persist in the hotter drier climates of Eastern Washington is as of yet undetermined. At risk are the $300 million cherry, $51 million juice grape, and $150 million wine grape crops. A list of effective chemicals, including new chemistries and rotation partners addressing insect resistance management and pollinator conservation, is necessary for the upcoming 2010 season in order to prevent economic losses by these industries. Extension research on first appearance, phenology between fruit ripeness and SWD oviposition and the bloom period will provide the impacted industries of Washington optimum timing for cover sprays. We will report on contact and residual efficacy of labeled compounds on red raspberry, blueberry and strawberry to adult SWD and determine rotational partners to minimize IRM while providing coverage on these fruits during their respective maturation and harvest periods.

2

DROSOPHILA SUZUKII: IN-LAB OVERWINTERING DATA AND REAL-TIME AREA-WIDE MANAGEMENT TOOLS

Vaughn M. Walton[1], Daniel T. Dalton[1], Wei Yang[2], Tom Peerbolt[3]

[1]Department of Horticulture, Oregon State University, 4017 Ag and Life Sciences Building, Oregon State University, Corvallis, OR 97331-7304
[2]North Willamette Research and Extension Center, Oregon State University, 15210 Miley Rd., Aurora, OR 97002
[3]Peerbolt Incorporated, 5261 N. Princeton St, Portland, OR 97203-5263

Spotted Wing Drosophila (SWD), *Drosophila suzukii*, is a recently identified invasive pest in Pacific United States and Western Canada with the first recordings made in California during 2008. Subsequent recordings were made on a widespread basis in Oregon, Washington and British Columbia during 2009. This pest attacks a wide range of small and stone fruits and damage has resulted in significant financial losses during 2008 and 2009.

Understanding the success of overwintering rates and temperature tolerance limits for local strains of SWD need to be evaluated. These data, together with data on developmental parameters, will be used to develop and validate a degree-day model for SWD, which is needed to time prescribed management options. In the present study, adults and pupae were first acclimated to 10°C and then subjected to five temperature regimes: 1°C, 3°C, 5°C, 7°C, and 10°C, and 8:16h, L:D for 42 days. Following 19 days of low temperature, a subset of individuals from each temperature regime was selected and subjected to -5°C for one week. Freeze-treated insects were replaced at their respective temperature treatments for 16 days. A mild 42-day period was then provided to represent early spring conditions (10°C at 12:12h, L:D). Insect survival rates will be discussed.

In order to have a comprehensive picture of SWD infestation levels in specific locations, field scouts in all regions will enter data using a protocol designed by OSU and private consulting personnel. An online-available database will allow researchers, cooperating personnel and growers to view field-specific data for different regions and time periods. The database will provide area-specific information for control measures in order to minimize the pool of SWD that may infect adjacent production areas. These databases and their use will be discussed.

3

ON-THE-FLY APPROACHES TO TACKLING *D. SUZUKII*

Amy J. Dreves
Oregon State University, Crop and Soil Science Department
3017 ALS Bldg., Corvallis, OR 97331
Amy.Dreves@oregonstate.edu; office (541) 737-5576

Infestations of the Spotted Wing Drosophila fly, *Drosophila suzukii* (Diptera: Drosophilidae; SWD), an exotic and invasive pest, were found in Oregon fruits in late fall 2009. These flies are native to SE Asia --China, Japan, Thailand, and Korea. The SWD can infest and has caused a great deal of damage to ripening to ripe fruit in its first year of discovery (20-80% loss). We have confirmed findings of SWD in 15 Oregon counties and over 15 fruits including, but not limited to, blueberries, raspberries, blackberries, strawberries, Asian pears, cherries, peaches, plum, fig, and grape. Oregon's Willamette Valley peach growers were also affected during late summer after SWD was found in August, 2009; losses ranged from 20-80% in some fruits. Crop losses from 20-40% were seen in Oregon's late season blueberries and raspberries. There is concern about SWD spread as the sheer variety of fruit crops and ornamental and native plant species with fruit that ripen at different times throughout the year may exacerbate persistence throughout the west coast. Thus, as the season progresses SWD densities may increase and disperse among numerous cropping systems, urban/rural habitats, and wildland plant communities (e.g., wild blackberries). The biggest concern expressed by growers is not having a solid plan for SWD control for the upcoming 2010 season.

Presently, there are no established management guidelines for this new pest in Oregon. A team of Oregon, California, Washington, and Canadian researchers is addressing questions of overwintering capability, spring emergence, timing of oviposition, fruit preference and susceptibility to better understand SWD phenology and effectively control SWD. Our 'best guesses' at identifying a management strategy and control recommendations for 2010 are being developed as questions are being answered, including seasonal monitoring, damage assessment methods, biological control, mass trapping, effective chemical pesticides, and sanitation techniques for conventional, IPM, and organic fruit systems. We will also present data on overwintering and timing of oviposition in the field. Our preliminary observations indicate that larvae, pupae and adults can survive fluctuating winter temperatures in Oregon. Extension activities are in place to provide a network of outreach programs including backyard participation, laminated educational cards and ID mounts, SWD newsletter, demonstration tours, You-Tube videos, and training workshops.

4

LABORATORY DATA ON SPOTTED WING DROSOPHILA OVIPOSITION, OLFACTION, AND CONTROL

Denny J. Bruck and Jana Lee
USDA-ARS Horticultural Crops Research Laboratory, 3420 NW Orchard Ave., Corvallis OR, 97330, (541) 738-4026, Denny.Bruck@ars.usda.gov

The spotted wing Drosophila, *Drosophila suzukii*, is a serious threat to small fruit production all along the west coast of the United States. The objectives of our research efforts are to begin to understand the biology of this insect in our region and develop IPM programs for its effective control. Laboratory studies were initiated in the fall of 2009 to determine the oviposition potential, olfactory cues, and control with pesticides currently registered for use on small fruit crops. Females are being monitored for ovipoisition daily on artificial diet over their lifespan. Olfactory response to commercially available semiochemicals is being screened in a four-arm olfactometer. Several pesticides applied directly to adult flies in the laboratory provided 100% control within 24hrs. The residual activity of the most efficacious products will be determined in the laboratory at 0, 1, 3, 7, and 14 days after application.

5

SPOTTED WING DROSOPHILA: POTENTIAL ECONOMIC IMPACT OF A NEWLY ESTABLISHED PEST

Mark P. Bolda[1], Rachael E. Goodhue[2] and Frank G. Zalom[3]
[1]UCCE, Santa Cruz and Monterey Counties, 1432 Freedom Blvd. Watsonville, CA, 95076
[2]Dept. of Agricultural and Resource Economics, Univ. of California, Davis, CA 95616
[3]Dept. of Entomology, Univ. of California, Davis, CA 95616

We provide preliminary estimates of economic losses due to SWD infestations. Rather than predicting actual economic damage due to SWD, our estimate is intended to illustrate the *potential scope* of economic damages. The significant gaps in scientific knowledge regarding the biology and control of SWD, coupled with the substantial degree of uncertainty regarding what is known, prohibit any sort of definitive economic analysis. Yield loss estimates from 2009 observations range from negligible to 80 percent, depending on location and crop. Using these estimates, we present preliminary estimates of economic losses due to SWD infestations of blueberries, blackberries and raspberries, cherries, and strawberries. We present state-level estimates for California, Oregon, and Washington. We illustrate how economic impacts to a specific production region can be more important than state-level measures indicate by evaluating the potential impacts on four coastal California counties. As is always the case, any economic impact analysis is subject to the uncertainties in underlying scientific analysis. In the case of SWD, because it is a recent invader and the international literature on the species surprisingly limited, the scientific uncertainty is tremendous and further research is required. In addition, our analysis computes losses based solely on the value of production for these crops. We do not take into account any increase in prices due to a reduced supply, which would offset to some extent the reduction in revenues due to the reduction in the quantity produced. Similarly, we do not consider any changes in consumer welfare that may occur. Finally, while efficacious control methods will reduce realized yield losses, they will also raise production costs to an

unknown extent. Nonetheless, in spite of these many considerations, it is apparent that there is substantial potential for certain crops and regions to incur economic damage as a result of the establishment of SWD.

6

SPOTTED WING DROSOPHILA ON STONE FRUIT IN CALIFORNIA: INVASION HISTORY, SEASONAL TRAPPING AND 2010 CONTROL PLANS

R. A. Van Steenwyk[1], J. L. Caprile[2], W.W. Coates[3] and P. W. Shearer[4]
[1]R. A. Van Steenwyk, UCCE, Dept. E.S.P.M., 137 Mulford Hall, Berkeley, CA 94720-3114
[2]J. L. Caprile, UCCE, Contra Costa County, 75 Santa Barbara Rd., Pleasant Hill, CA 94523
[3]W.W. Coates, UCCE, San Benito County, P.O. Box 1956, Hollister, CA 95024-1956
[4]P. W. Shearer, OSU-MCAREC, Hood River, OR 97031

The invasion history of spotted wing drosophila (SWD) in California from berries to cherries and then the spread within the state will be discussed. Efficacy, advantages and disadvantages of bait trap design and baits will be discussed along with 2009 seasonal monitoring of SWD. 2010 chemical control (efficacy, PHI and REI) for SWD on California and Pacific Northwest cherries will be discussed.

7

DROSOPHILA SUZUKII: GROUND ZERO

Frank Zalom[1] and Mark Bolda[2]
[1]Dept. of Entomology, Univ. of California, Davis, CA 95616
[2]UCCE, Santa Cruz and Monterey Counties, 1432 Freedom Blvd. Watsonville, CA, 95076

An unusual outbreak of a *Drosophila* that was infesting marketable fruit was noticed in the Monterey Bay Area of California during Fall 2008 and resulted in 'phenomenal rates of fruit infestation in both strawberries and caneberries', well over 50% in some cases. This insect was later identified as the spotted wing drosophila, *Drosophila suzukii*. The fly has now been reported from virtually all coastal California counties and a number of central valley counties as well. Descriptions of damage to caneberries and strawberries, and results of monitoring and control studies in the Monterey Bay area that have been ongoing since Fall 2008 are presented.

SYMPOSIUM: BIOLOGICAL CONTROL AND IPM OF CEREAL LEAF BEETLE IN WESTERN NORTH AMERICA

8
CEREAL LEAF BEETLE MANAGEMENT IN MONTANA

Patricia Denke[1], Gary Adams[2], Ian Foley[1]

[1]Montana State Department of Agriculture, 303 N Roberts, PO Box 200201, Helena MT 59602
[2]USDA-APHIS-PPQ, 1220 Cole Avenue, Helena, MT 59601

Cereal leaf beetle has been a sporadic problem in Montana since its introduction approximately 20 years ago. Early on, the beetle was a problem not only due to feeding by the immatures, but also due to adult feeding on the emerging cotyledons. In the first few years, several S18 and 24C labels for specific materials were issued in the state, and emergency spraying occurred regularly. Later, releases of *Tetrastichus julis* happened, first in the same areas as the initial discoveries of the pest, and subsequently in other areas with infestations. As more counties were infested, *T. julis* seemed to begin to move throughout the state without human intervention. *Anaphes flavipes* was introduced later. However, detecting establishment of this parasitoid was very difficult. Over time, several populations were established, and some redistribution efforts were accomplished by the USDA. In addition, the USDA APHIS PPQ group in Montana provided material to the Niles, Michigan lab for work for several summers. At the present time, CLB is a minor problem in several areas of the state, but remains a threat, particularly in irrigated areas. No S18 or 24C labels have been requested for several years.

9
BIOLOGICAL CONTROL OF CEREAL LEAF BEETLE IN OREGON

G.W. Brown[1], B.B. Bai [2], S. Rao [3]

[1] USDA, APHIS-PPQ, Portland, OR 97218
[2] Oregon Department of Agriculture, Salem, OR 97301
[3] Oregon State University, Corvallis, OR 97331

The cereal leaf beetle (CLB) *Oulema melanopus* (Coleoptera: Chrysomelidae) is a serious pest in cereal crops and forage grasses. It was first reported in Oregon in 1999. Annual statewide surveys have detected this invasive pest in 21 Oregon counties. Immediately after the detection of CLB, Oregon began a cooperative CLB biocontrol program among Oregon Department of Agriculture (ODA), USDA, Oregon State University (OSU), and the affected industry. Initially a three-year study was undertaken to determine the phenology of CLB in the diverse climatic zones of Oregon to assist with timing and success of the biocontrol releases.

Management of CLB in the West has focused on classical biological control strategies based on the early success of this method in the eastern United States. The egg parasitoid, *Anaphes*

flavipes and the larval parasitoid *Tetrastichus julis* were initially provided to Oregon by cooperators in CO, MI, MT, UT, and WY. The program started three field insectaries for the egg parasitoid *Anaphes flavipes* (Hymenoptera, Mymaridae) and four insectaries for the larval parasitoid, *Tetrastichus julis* (Hymenoptera, Eulophidae). Since 1999, about 114,000 egg parasitoids and 397,000 larval parasitoids were released in Oregon. Recovery samples show parasitism rates for the egg parasitoid reached 30% at one site. Many larval parasitoid sites now have 100% parasitism rate. Recoveries of *T. julis* in fields up to 35 miles from where it had been released, suggest that *T. julis* is actively spreading in contiguous grain growing regions of Oregon.

In areas without effective biocontrol, insecticide applications may provide immediate control of CLB. An annual survey of the economic impact of CLB in Oregon found acres treated with pesticides for CLB in Oregon have continually increased from no acres treated in 1999 to 64,200 acres in 2004. After *T. julis* reached high parasitism levels over large areas, treated acreage decreased to 19,141 acres in 2007 suggesting that biocontrol, in combination with other possible factors, has been successful in decreasing pesticide use in Oregon.

10
INTEGRATED CLB MANAGEMENT PROGRAM IN OREGON: ECONOMIC THRESHOLD, HOST RANGE, AND PHEROMONE MONITORING

Darrin Walenta[1] and Sujaya Rao[2]

[1]Oregon State University, Union Extension Service,
10507 N McAlister Rd, La Grande, OR
[2]Oregon State University, Department of Crop and Soil Science, 3017 ALS, Corvallis, OR

The Cereal leaf beetle (CLB), *Oulema melanopus* (Coleoptera, Chrysomelidae), is an invasive new pest of economic concern to cereal grains, grass forage/seed crops and other grass-host species in Oregon and the Pacific Northwest (PNW) region. CLB was first identified in Oregon in 1999 and has since been detected in a total of 20 Oregon counties to date. CLB spread and establishment occurred rapidly due to the absence of natural predators, thus, insecticide application has provided the only effective means of control available to the growers. In response to the CLB threat, a series of research, extension, and biological control projects were conducted in an effort to develop an integrated CLB management program. Here we present results related to the following studies: 1) Determination of the impact of CLB populations on winter and spring wheat crops grown in northeastern Oregon and investigations on the efficacy of current economic threshold levels utilized for CLB management; 2) Evaluation of the impact of CLB on grass seed crops raised in Oregon; and 3) Assessment of the CLB aggregation pheromone as a monitoring tool, especially in the spring, when over-wintering beetles move into new fields. Results of the three studies will be presented, and the current status of the pest after implementation of CLB biological control in the region will be presented.

11
FOREIGN EXPLORATION FOR CEREAL LEAF BEETLE BIOLOGICAL CONTROL AGENTS IN CHINA

Barry B. Bai[1], Keith S. Pike[2] & Terry D. Miller[3]

[1]Oregon Department of Agriculture, 635 Capitol St NE, Salem, OR 97301
[2] Washington State University, IAREC, 24106 N. Bunn Rd, Prosser, WA 99350
[3] Washington State University, Department of Entomology, Pullman, WA 99164

A three-year foreign exploration project to search for cereal leaf beetle natural enemies in China was funded by USDA during 2002, 2003 and 2007. This was a collaborative project involving ODA, WSU and China to find new effective biological control agents for the cereal leaf beetle problem in the Pacific Northwest. Each year, US scientist(s) traveled to China during spring or summer, and collected extensively with Chinese collaborators in several provinces including Shaanxi, Xinjiang and Fujian. Contacts were also established in Beijing and Shanghai for future cooperative works.

In each province, the local Chinese collaborators would survey the relevant fields before arrival of the US scientist. The US/China team collected in the fields of rice in Fujian, spring wheat in Xinjiang and millet in Shaanxi. The third year was mainly focused on Fujian in the southeastern China. The rice leaf beetle *Oulema oryzae* and its egg parasitoid *Anaphes nipponicus* were collected from Fujian, and were shipped to Washington State University's quarantine facility for further screening and host range/non-target testing. The emerged parasitoids attacked CLB eggs readily in the quarantine facility and successfully completed one generation in the CLB eggs. The *Anaphes nipponicus* has the potential to be an effective biological control agent for cereal leaf beetle.

12
BREAKING DIAPAUSE IN THE CEREAL LEAF BEETLE, *OULEMA MELANOPUS*: A CRITICAL STEP IN YEAR-ROUND EGG PRODUCTION FOR CULTURING PARASITOIDS

Dan Bean and Colleen Jandreau

Colorado Department of Agriculture, Biological Pest Control, Palisade, CO 81526

The cereal leaf beetle overwinters in reproductive diapause and emerges in the spring, feeds and initiates reproductive development. Beetles lay eggs for several weeks, producing the next generation with adults emerging in early to mid summer. Newly emerged adults feed heavily then enter reproductive diapause with no mating or ovipostion and this obligatory diapause brings about a univoltine life cycle. As a consequence it is only possible to obtain field-collected beetles for egg production in the spring. As part of our efforts to rear the egg parasitoid, *Anaphes flavipes*, we tested different potential diapause terminating regimes as well as different beetle culturing densities, to maximize egg production within a laboratory setting.

We received shipments of field-collected overwintering generation beetles from cooperators in Utah, Washington and Oregon. They were fed ad libitum with either oats or barley and allowed to seek overwintering sites in paper towels or rolls of corrugated cardboard. Beetles were stored at -5°C for 8-16 weeks then brought out, fed and observed for mating and ovipostion. Beetles began laying eggs about three weeks after they were brought out of freezing conditions, and continued to oviposit for another two weeks. The egg yield was less than 10/ beetle. Other experiments showed a decline in yield (eggs/beetle) with increasing densities of adults.

These results are discussed in reference to future needs of the CLB biocontrol program, including the possibility that a steady supply of CLB eggs will be needed for egg parasitoid production.

13
INVASIONS OF WESTERN CANADA BY THE CEREAL LEAF BEETLE AND STRATEGIES FOR POPULATION MANAGEMENT

Lloyd Dosdall[1], Héctor Cárcamo[2], Owen Olfert[3], Scott Meers[4], Scott Hartley[5], John Gavloski[6]

[1]Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, [2]Agriculture and Agri-Food Canada, Lethbridge Research Centre, Lethbridge, AB, [3]Agriculture and Agri-Food Canada, Saskatoon Research Centre, Saskatoon, SK, [4]Alberta Agriculture and Rural Development, Brooks, AB, [5]Saskatchewan Agriculture and Food, Regina, SK, [6] Manitoba Agriculture, Food and Rural Initiatives, Carman, MB

The cereal leaf beetle, *Oulema melanopus* L. (Coleoptera: Chrysomelidae), is the most recent of a series of insect pests to invade agroecosystems in the western Canadian prairie provinces. The species was first found in southern Alberta near Lethbridge in 2005, and from 2006 to 2009 inclusive, commercial cereal crops in southern Alberta were sampled for adults and larvae of *O. melanopus*. Fields in southern Saskatchewan were monitored in 2008 and 2009. Larval specimens were also examined for evidence of parasitism by *Tetrastichus julis* (Walker) (Hymenoptera: Eulophidae), the parasitoid introduced previously to North America for biological control of cereal leaf beetle and known to be instrumental in its control in several other regions. Our surveys indicated that winter wheat, *Triticum aestivum* L., is the primary host of cereal leaf beetle throughout southern Canada. A gradual increase in the distribution and abundance of *O. melanopus* occurred in southern Alberta and Saskatchewan from 2006 to 2008, with a much greater population expansion observed in 2009. The occurrence of *T. julis* at the same site near Lethbridge, AB for three consecutive years indicates that the parasitoid has established and overwintered successfully in western Canada. The discovery in 2009 of an isolated population of *O. melanopus* in northwestern Manitoba represents a new invasion rather than dispersal from regions further west in Saskatchewan and Alberta because the nearest source populations in Saskatchewan are located more than 500 km away. The most likely invasion route of *O. melanopus* to western Canada is from source populations in Montana followed by northward movement to southern Alberta. There are no geographical or ecological barriers in western Canada that can prevent its further dispersal throughout the agricultural heartland of western Canada. Research to manage *O. melanopus* populations will adopt an integrated approach with emphasis on classical biological control.

14
INSECTICIDE TOXICITY EFFECTS ON WASP PARASITIODS OF CEREAL LEAF BEETLE

Keith S. Pike[1], Terry Miller[2], Diana Roberts[3]

[1]Washington State University, 24106 N Bunn Rd, Prosser, WA 99350
[2]Department of Entomology, Washington State University, PO Box 6382, Pullman, WA 99164
[3]Washington State University Extension, 222 N Havana St, Spokane, WA 99202

Toxicity effects of broad spectrum (lambda-cyhalothrin) and selective (flonicamid, pymetrozine, spinosad) insecticides on egg and larval parasitoids (*Anaphes flavipes* and *Tetrastichus julis*, respectively) of cereal leaf beetle (CLB, *Oulema melanopus*) were determined through in-lab replicated testing. The evaluations were done in controlled environments where parasitoids were placed in tubes with treated wheat. Parasitoid survival curves were established for each treatment compared against an untreated check. Based on two years of evaluations, flonicamid was the least toxic of the insecticides to CLB parasitoids. If this product were to be registered on wheat for use against cereal aphids, it would be relatively safe to CLB parasitoids. Pymetrozine, in 3 of 4 trials caused light to modest reductions in survival. Spinosad, an effective insecticide against CLB larvae and adults, was relatively toxic to the parasitoids.

15
IMPACTS OF EARLY SEASON IPM ON CEREAL LEAF BEETLE

David Bragg

Washington State University Extension, 757 Main Street, Pomeroy WA 99347

Recent research trials conducted in SE Washington show yield damage by Cereal Leaf Beetle above the new economic threshold of 2 larvae plus 1 adult at jointing stage of crop development in both spring wheat and spring barley cereal grain crops. Even a week of CLB feeding during this crop stage had an impact on crop yield.

Trial research also included removing flag leaves at different levels of damage, e.g. 0%, 10%, and 20%, etc, to no flag leaf. Flag leaf removal had no effect on yield. Three years of insect cycles compared to spring ambient temperatures have been completed and graphed to show trends of dates of arrival of CLB and its major predator *Hippodamia convergens*. If the ladybird predators arrive close to the time of CLB moving from winter wheat to spring grains effective biological control takes place. CLB arrival after spring grain jointing very little damage occurs and the ladybird beetles consume eggs through early 3rd instar CLB stages.

T. julius, a parasitoid, infests as much as 95% of late 3rd instar through prepupal larvae at CFRF making for a complete biological package most growing seasons.

16

BIOLOGICAL CONTROL OF CEREAL LEAF BEETLE IN WASHINGTON STATE

Diana Roberts[1], Terry Miller[2], Keith Pike[3], Steve Miller[4], David Bragg[5], Mike Klaus[6]

[1]Washington State University Extension, 222 N Havana St, Spokane, WA 99202
[2]Department of Entomology, Washington State University, PO Box 6382, Pullman, WA 99164
[3]Washington State University, 24106 N Bunn Rd, Prosser, WA 99350
[4]USDA-APHIS-PPQ, 222 N Havana St, Spokane, WA 99202
[5]Washington State University Extension, P O Box 190, 757 Main St, Pomeroy WA 99347
[6]Washington State Department of Agriculture, 21 N 1st Ave Ste 103, Yakima WA 98902

The Washington State Department of Agriculture (WSDA) discovered cereal leaf beetle (CLB) *Oulema melanopus* (Coleoptera: Chrysomelidae) in Washington State in 1999. In 2000 they made the first releases of the larval parasitoid, *Tetrastichus julis* (Walker) (Hymenoptera: Eulophidae), in a field insectary at Nine Mile Falls. Washington State University Extension assumed leadership of the project in 2003, and subsequently established a total of 12 insectaries at CLB hotspots across the cereal grain-producing areas of the state. Initially the larval parasitoid was imported from Utah, Montana, and Wyoming. Later *T. julis* was collected as parasitized CLB larvae from established insectaries in Washington State and redistributed in areas with new CLB infestations. Weekly sampling at the insectaries showed that the pest population crashed as the level of parasitism in CLB larvae exceeded 90%. Observations indicated that 70% parasitism in farm fields was the equilibrium level between CLB and the parasitoid at which insecticides were not needed. By 2007 and 2008, samples from farm fields showed the parasitoid had moved on its own across the state, following CLB movement. Parasitism levels in CLB in dryland areas routinely exceeded 90%. In irrigated areas of the Columbia Basin, where insecticides were used more commonly, parasitoid populations are not yet high enough to manage CLB. Farmers here may need to withstand some yield loss to enable the parasitoid to multiply to equilibrium levels.

10-MINUTE STUDENT PAPER COMPETITION
MASTER'S PAPERS

17SP
NATIVE BEE ABUNDANCE AND FLORAL RESOURCE AVAILABILITY IN AN OREGON VALLEY EPHEMERAL WETLAND PRAIRIE SYSTEM

J.E. Bergh, S. Rao, W.P. Stephen
Oregon State University, 3017 ALS Building, Corvallis, OR

Wetlands and associated native ecosystems provide critical food resources and nesting habitat for native bees, which are critical for pollination particularly of rare plants. The objective of this 3-year study in a fragmented wetland conservation site on the West Eugene Wetlands in western Oregon was to examine the relationship between bee abundance and availability of floral resources as well as plant-insect interactions between the bee fauna and remnant rare plant populations. A census of bee diversity was conducted using visual attractant traps and timed observations, and abundance was analyzed in correlation with native plant phenology. Data on species richness and forage plant bloom phenology will be presented, and the implications of these findings for land management will be discussed.

18SP
A COMPARISON OF BEE DIVERSITY ACROSS SAND DUNE HABITATS AT ASH MEADOWS NATIONAL WILDLIFE REFUGE.

Nicole F. Boehme, David A. Tanner, and James P. Pitts
Biology Department, Utah State University, 5305 Old Main Hill, Logan UT 84322

Discovering nesting locations of potential pollinators, such as bees (Hymenoptera), is often difficult and fortuitous, even when specific information is known regarding nesting site preferences for a particular species. Passive collecting techniques provide a means to survey for pollinators in a particular habitat without the waste of time, funds, or manpower. To determine the distributions and possible nesting sites of potential pollinators of rare or endangered plants, we sampled habitats on Ash Meadows National Wildlife Refuge using three trapping methods. We narrowed our search efforts by focusing on sand dunes, because sand dunes are known to provide nesting habitat for bees. Some non-sand dune habitats were also sampled to include bees that may not be psammophilous. Our collecting methods included pan traps, malaise traps, and net collecting. The Sørensen's similarity index was used to compare bee species richness across our sand dune and non-dune collection sites. We discuss species-specific variation in diversity and abundance between sites, compare several environmental variables, and associate the distribution of bees with the pollination of the rare and endanger plant species on Ash Meadows. This data is essential for pollinator management and conservation.

19SP

IMPACT OF POTATO PSYLLID (HEMIPTERA: TRIOZIDAE) DENSITY ON ZEBRA CHIP POTATO DISEASE INCIDENCE, YIELD AND TUBER PROCESSING QUALITY

Jeremy Buchman[1], Joseph Munyaneza[2] and David Horton[2]
[1] Washington State University, Department of Entomology, Pullman, WA 99164
[2] USDA-ARS, 5230 Konnowac Pass Rd, Wapato, WA 98951

Zebra chip is an emerging and devastating disease of potatoes in the southwestern United States, Mexico, Central America and New Zealand, causing millions of dollars in crop losses annually. Infected plants develop tubers having necrotic stripes, making tubers commercially unmarketable. The disease has been associated with the potato psyllid, *Bactericera cockerelli* (Sulc) and the bacterium *Candidatus* Liberibacter solanacearum/ psyllaurus. Effective management strategies for plant pathogens vectored by insects require knowledge of transmission rates and the role of vector density in transmission. Current control efforts for zebra chip focus on heavy, prophylactic insecticide sprays to control the vector, but little is known regarding how many psyllids are needed to transmit the pathogen and cause the disease. The objective of our study was to assess the correlation between potato psyllid density and incidence of zebra chip, yield, and tuber processing quality. Greenhouse studies showed that density as low as one insect per plant can effectively cause zebra chip. Similarly, potatoes grown under field conditions and exposed to low densities of psyllids experienced losses in yield and reduction in tuber quality that were similar in magnitude to what is observed in potatoes exposed to high densities of the vector. These results suggest that even a very low number of liberibacter-infective psyllids can cause disease expression and yield loss in potatoes.

20SP

IS THE ENDANGERED PLANT *ASTRAGALUS PHOENIX* (FABACEAE) POLLINATOR LIMITED?

Catherine M. Clark and James P. Pitts
Utah State University, 5305 Old Main Hill, Logan, UT

Ash Meadows National Wildlife Refuge is a desert oasis found in Nye County, NV. It is home to 12 threatened, rare, or endangered plants. *Astragalus phoenix* is among the plants listed as threatened by the federal government and considered endangered in Nevada. A comparative, pollinator exclusion study was conducted to determine if pollinators impact the reproductive success of *A. phoenix* and to determine if pollinator rareness contributes to the limited distribution of this plant. A comparison was made to a closely related plant, *A. utahensis*, found in Cache Valley, UT. This plant was chosen for comparison due to its morphological similarity, distribution, and commonness. Both species of plants were either covered to exclude pollinators or left open; visitation rates were calculated, visitors collected, and blooms, fruits and seeds were counted. Statistical analyses were employed to determine if noted differences between the two plants were significant.

21SP
EVALUATING THE EFFECTS OF AGRICULTURAL MANAGEMENT ON GROUND BEETLES (COLEOPTERA: CARABIDAE) IN THE PNW

Jessica M. Green, Ed Peachey, Alysia Greco, and Laurel Moulton
Oregon State University – Dept. of Horticulture – 4017 ALS. Corvallis, OR 97331

One of the goals of sustainable agriculture is to reduce pesticide load by promoting, maintaining, and conserving natural enemies of common pests. Carabid beetles are known to be effective predators against aphids, cutworms, slugs, and other soft-bodied prey[1]. Recent studies also suggest that granivorous carabids may be effective in reducing weeds in agro-ecosystems[1,3]. However, in order to predict predation rates, and thus efficacy, we must first understand how farm management affects beneficial beetle populations. This research aims to quantify carabid response to varying levels of perturbation common in vegetable production agriculture. A 3^2 factorial field study was conducted to measure changes in ground beetle activity-density (AD) and species abundance over 3 growing seasons. In June 2007, 10x20m plots were fenced with landscape fencing and subjected to either conventional or reduced spring tillage (SPR). Bifenthrin and Mocap[tm] were also applied to main plots (INS). Plots were split in Sept. 2007 and assigned either pre-plant tillage or direct-seeding of a barley/vetch cover crop (FALL). SPR and INS treatments were repeated in 2008. Beetles were sampled from dry pitfall traps (n=96) and re-released. Results indicate that *Pterostichus melanarius* AD was highest in INS+ plots, particularly in 2009 ($F=10.1^{***}$). Conversely, INS+ negatively affected *Amara* spp. in 2009 ($F=6.7^{**}$) but reduced spring tillage seemed to mediate that effect. Statistical differences of evident treatment effects were greatest in year 3. These and other results suggest that agricultural management has a cumulative effect on carabid AD. Genus-specific responses may be due to spatial and temporal synchronicities that exist between disturbance events and carabid reproduction patterns.

22SP
WORKING OUT THE BUGS IN SEX RATIO DISTORTION IN THE NORTHERN FOWL MITE (*Ornithonyssus sylviarum*)

John McCulloch
Washington State University, Department of Entomology, 100 Dairy Rd., Pullman, WA

The northern fowl mite (*Ornithonyssus sylviarum*; NFM) is a common pest of poultry in the United States. This blood-feeding ectoparasite is believed to have haplo-diploid sex determination and is known to have highly skewed sex ratios (e.g. 80% female). The actual mechanism(s) of sex determination for NFM remains unknown, including the possible effects of endosymbiotic bacteria that are known to alter sex ratios of many arthropod taxa. The influence of mating on sex determination is being investigated. Using a nested PCR method, 15 Northern Fowl Mite (NFM) populations from infested poultry farms across the United States and one population from Sweden were screened for the presence of three sex-ratio distorting endosymbionts: *Wolbachia*, *Cardinium*, and *Spiroplasma*. *Wolbachia* and *Spiroplasma* were detected in multiple populations with some populations being doubly infected. *Cardinium* was

not detected in any of the populations sampled. The detection of these endosymbiotic bacteria in NFM may explain the often female-biased sex ratio of NFM populations, which would provide insight to possible modes of gene flow regulation within and between populations of NFM. Knowledge of endosymbionts infecting NFM may also provide new innovative methods to manage this economically costly pest.

23SP
ALTERNATIVE CONTROLS OF BLACK VINE WEEVIL (*OTIORHYNCHUS SULCATUS*) IN CRANBERRIES

Betsey Miller[1], Denny Bruck[2], Linda White[3], Kim Patten[4], Vaughn Walton[1]
[1]Oregon State University, Department of Horticulture, 4017 Agriculture and Life Sciences Building, Corvallis, Oregon 97331, [2]USDA Horticultural Crops Research Laboratory, 3420 NW Orchard Avenue, Corvallis, Oregon 97330, Oregon State University, Coos County Extension Service, Ohlsen Baxter Building, 631 Alder St.
Myrtle Point, Oregon 97458, [4]Washington State University, Long Beach Research and Extension Unit, 2907 Pioneer Road, Long Beach, Washington 98631

Black vine weevil (*Otiorhynchus sulcatus*) is an important pest in cranberry production in the Pacific Northwest. It is estimated that as many as one dozen black vine weevil in a square meter will cause vine death within a couple of years. Black vine weevil is hard to manage, due in part to difficulties finding the pest early and identifying associated symptoms. Economic and action thresholds can be defined by determining the relationship between black vine weevil density and plant health. This paper will present data on initial egg density and the associated impact on cranberry plant health. In addition to the difficulty of monitoring black vine weevil, the quantity of available effective conventional control options is dwindling. There is a need to develop pest management options that have less impact on water and soil quality, non-target organisms and human health and safety. Entomopathogenic fungi, *Metarhizium anisopliae*, have been demonstrated to be a viable, sustainable alternative control for black vine weevil in other production systems. The research presented in this paper evaluates the use of *M. anisopliae* in cranberries in comparison to products currently used by cranberry growers, including entompathogenic nematodes (*Steinernema kraussei*) and Imidichloprid. Data will be presented on efficacy against black vine weevil larvae as well as persistence in the field over time.

24SP
ATTRACTION OF *THAUMATOMYIA GLABRA* (MEIGEN) (DIPTERA: CHLOROPIDAE) MALES TO METHYL ANTHRANILATE FROM *IRIS* FLOWERS

B. Ohler[1], C. Guédot[2], R. Zack[1], P. Landolt[2]
[1] Washington State University, Pullman, Washington, U.S.A.
[2] USDA-ARS Yakima Agricultural Research Laboratory, Wapato, Washington, U.S.A.

Large numbers of *Thaumatomyia glabra* (Meigen) (Diptera: Chloropidae) were observed congregating on flowers of *Iris pallida veriegata* while none were observed on nearby *Iris germanica* flowers. Sampling of *T. glabra* on *Iris pallida veriegata* flowers revealed the presence of only males. It was previously reported that *T. glabra* males were attracted to methyl anthranilate. The objective of this study was to determine the presence of methyl anthranilate in flowers of both species of *Iris.* Methyl anthranilate was found in extracts of *I. pallida veriegata* flowers but not in extracts of *I. germanica* flowers. This study suggests that *I. pallida veriegata* flowers are attractive to *T. glabra* males because they release the sex specific attractant methyl anthranilate. *Iris germanica* flowers were not attractive to *T. glabra* males, probably because they to do not produce this chemical.

25SP
BUMBLE BEES VERSUS HONEY BEES: A COMPARISON OF POLLINATION SUCCESS IN OREGON CRANBERRIES

Kim Phillips[1], Sujaya Rao[2], Bill Stephen[2] and Linda White[1]
[1]Oregon State University Extension Service-Coos County, Myrtle Point, OR 97458
[2]Oregon State University, Crop and Soil Sciences Dept, 3017 ALS, Corvallis, OR 97331

Cranberries (*Vaccinium macrocarpon*), an important crop of cool, cloudy, and windy Southwestern Oregon, face the obstacle of pollination, the necessary precursor to fruit-set. Honey bees (*Apis mellifera*), well known as fair-weather foragers, are rented by farmers in large numbers to saturate the area with pollinators. Their increasing price, decreasing availability, and questionable pollinator efficacy are motivating Oregon cranberry farmers to seek alternative pollinators. Native bumblebees (*Bombus* sp.) forage on cranberries even under unfavorable weather conditions that keep honeybees indoors. However, their impact on cranberry pollination under Oregon conditions is not known.

Our objective was to compare pollination by honey bees and bumble bees in Oregon cranberries. Colonies were connected to 1m x 1m cages and the following treatments were compared: 1) bumble bees; 2) honey bees; 3) control (no bees); and 4) open pollination (all bees). The experiment was set up in two separate cranberry beds with four replications. Pollination success was evaluated using the following parameters: berry yield (g/m^2), number of berries/m, size of berries, and number of seeds/berry. An analysis of variance indicated that for all measurements, honey bees and bumble bees did not differ significantly from each other. However, due to cage effect, yield in bee pollinated cages was lower than yield in open pollinated plots. Options for build-up of bumble bee populations for enhancing cranberry pollination will be discussed.

26SP
ECONOMIC INJURY LEVELS FOR PEA APHID ON DRY PEAS

Brad S. Stokes & Edward J. Bechinski
Division of Entomology, University of Idaho, Moscow, Id

We conducted a field experiment during the summer of 2009 to quantify the relationship between the density of pea aphids (*Acyrthosiphon pisum*) and the yield of dry peas (*Pisum sativum* 'Aragorn'). Aphids from insectary colonies were placed inside A-frame screen cages at six different densities (0, .22, .5, 1, 5 and 15 aphids per plant) replicated 4 times. Cages enclosed 18 plants; the center 10 plants were reserved for overall seed yield and the remaining 8 plants were sampled for aphids 3, 10 and 17 days after aphid establishment. Infestations were terminated on day 17 by spraying plants with insecticidal soap and removing the A-frame cages. Plant seed yield was hand harvested on August 6. Relative seed yield decreased as a linear function of aphids per plant at the beginning of flowering (49 days after plant emergence). The best-fit statistical model was $y = -0.0035x + 0.6681$ ($n = 22$, $r^2 = .656$), where y is relative crop seed yield and x is aphid density per plant. Economic injury levels were computed with the formula EIL = C/V Y D K, where C is control cost ($/acre), V is crop value ($/cwt), Y is yield potential (cwt/acre), D is damage per aphid as given by the slope coefficient from the linear regression and K is the insecticide killing power. EIL values ranged from 10 to 39 aphids per plant. We will repeat this work during the 2010 growing season and will expand the study to quantify pest:yield relationships during the vegetative growth stage of peas.

27SP
EXPLORING THE EFFECTS OF HOST IMMUNE RESPONSE ON FACTORS THAT LEAD TO POPULATION DYNAMICS AND PATHOGEN TRANSMISSION

Ann Vander Vliet[1], Glen Scoles[2], Jeb Owen[1]
[1]Department of Entomology, Washington State University, Pullman, WA
[2] USDA–ARS, Animal Disease Res. Unit, Washington State University, Pullman, WA

The Rocky Mountain Wood Tick (*Dermacentor andersoni*; RMWT) is an important ectoparasite of cattle in the western United States, where it is responsible for the transmission of the rickettsial pathogen *Anaplasma marginale* among cattle. The effects of host variation on tick fitness are poorly understood, including the impact of host immune responses to tick infestation. We used two morphologically different populations from Stevensville, MT and Burns, OR in our experiments. Our first experiment assessed survival under different environmental conditions using 25ºC and 32ºC and 70% and 98% humidity to simulate differing conditions between the two collection sites. Our next experiment assessed the effects of host immune response and *A. marginale* infection on tick fitness. A feeding gradient was used in which ticks were fed on uninfected and infected cattle that had differing tick feedings (exposures). We documented a difference in larval survival under the different environmental conditions. Female repletion weight, as well as egg mass weight, was negatively affected when ticks fed on calves with multiple tick exposure. Understanding tick fitness relative to host immunity and *A. marginale* infection will lead to a better understanding of tick population dynamics and disease transmission. These results may give us clues to controlling pathogen transmission and future management strategies.

10-MINUTE ORAL PAPER PRESENTATIONS, PART 1 of 2
(ADDITIONAL 10-MINUTE PAPERS #74-97)

28P
INHIBITION OF *LYGUS HESPERUS* EGG DEVELOPMENT AT HIGH AND LOW TEMPERATURE EXTREMES: USE OF A BIOPHYSICAL MODEL

W. Rodney Cooper and Dale W. Spurgeon
USDA-ARS 17053 North Shafter Avenue, Shafter, CA

Linear regression models can over or under estimate temperature-dependent development rates of insects at temperatures near developmental thresholds. The biophysical model for temperature-dependent insect development is capable of describing development rates where high and/or low temperature inhibition is encountered. We measured the development rates and survival of *Lygus hesperus* eggs at 10 constant temperatures (10, 12.8, 15.6, 21.1, 26.6, 29.4, 32.2, 35, 37.8, and 40.6 °C). Development rates were fit to a biophysical development rate model and egg survival was analyzed among temperatures. In a separate study, egg development and survival at 26.6 °C was examined after exposures to 10 °C for 2 to 20 days with 2-d increments. Results from these studies improve our understanding of temperature-dependent development and survival of *L. hesperus* eggs.

29P
THE FATE OF CODLING MOTH IN APPLES EXPORTED TO TROPICAL COUNTRIES

Lisa G. Neven
USDA-ARS, Yakima Agricultural Research Laboratory, 5230 Konnowac Pass Rd,, Wapato, WA

The potential presence of codling moth, *Cydia pomonella* (L.) in apples exported to tropical countries has caused various quarantine restrictions on the import of these fruits. In particular, the 'three strikes' policy imposed by Taiwan on apples exported from the Western U.S. has been particularly problematic to the industry. If three separate interceptions of codling moth larvae in fruit have occurred, the entire export program is suspended for the rest of the season. Although initial risk assessments indicated that establishment of codling moth in Taiwan would be unlikely to occur, there were no data to support the likelihood of codling moth survival and establishment under tropical conditions. Experiments were designed to determine the ability of codling moth to complete diapause and emerge under typical postharvest handling and shipping conditions followed by subsequent exposure to tropical conditions (i.e. photoperiods of 12:12 L:D at 20°C). No codling moths emerged from apples that were not cold stored at 3.3°C. There was only a 0.125% chance that any moths from fruit that had been cold stored for any duration would emerge as moths. Of those moths that emerged, only 25% emerged within a 6-week period. It was determined that it was highly unlikely that any progeny from a highly unlikely mating pair would ever complete diapause and emerge as moths. These data will be used to re-assess the risk of codling moth establishing in tropical climates.

30P
EFFECTS OF EGG LOAD ON THE OVIPOSITION BEHAVIOR OF THE GLASSY-WINGED SHARPSHOOTER

Mark Sisterson
USDA-ARS, Parlier, CA 93648

Egg load (number of mature eggs carried by an adult female) is commonly hypothesized to affect oviposition behavior. The effects of egg load on oviposition behavior of the glassy-winged sharpshooter, *Homalodisca vitripennis* (Hemiptera: Cicadellidae), were assessed through a series of laboratory bioassays. First, choice and no-choice tests were completed to determine relative preference of females for ovipositing on one of three host plant species. Subsequently, effects of egg load on acceptance of the low ranked and high ranked ovipositional host were assessed. For both hosts, time to deposition of the first egg mass decreased as egg load increased. For females with a given egg load, eggs were deposited sooner on the high ranked host than on the low ranked host. The results confirm that egg load affects ovipositon behavior of the glassy-winged sharpshooter. Thus, understanding factors that affect egg load is critical to understanding host use patterns of this invasive insect.

31P
LABORATORY REARING ALTERS THE DIAPAUSE RESPONSE OF *LYGUS HESPERUS*

Dale W. Spurgeon[1], Colin Brent[2]
[1]USDA, ARS 17053 N. Shafter Ave., Shafter, CA
[2]USDA, ARS 21881 N. Cardon Lane, Maricopa, AZ

Diapause in the western tarnished plant bug, *Lygus hesperus* Knight, is controlled by photoperiod. Previous reports of diapause contain inconsistencies, likely because of differences in the criteria used to distinguish diapause. We reared bugs from a laboratory colony at 26.6°C under 10- and 14-h photoperiods and assessed diapause status at adult ages from 3 to 17 days. The fat bodies of diapausing bugs were abundant and arranged in a specific configuration. The most appropriate criteria for distinguishing diapause appeared to be hypertrophied fat bodies combined with undeveloped medial accessory glands (for males) or undeveloped ovaries (for females) in adults that were at least 10 days old. We also evaluated less stringent criteria, permitting some development of accessory glands or ovaries to accommodate the delayed reproductive development observed in some specimens reared under the 10-h photoperiod. However, we observed a much lower incidence of diapause than was previously reported. In a follow-up experiment we compared the diapause response of bugs from a laboratory colony with that of bugs hatched from eggs laid by field-collected adults. For both genders, 10-d-old adults reared from eggs laid by field-collected adults exhibited a much stronger diapause response than did adults originating from the colony.

32P
TWO FOR THE PRICE OF ONE: NON-TARGET EFFECT OF DIMILIN ON HORN FLY EMERGENCE

Bryan Stevens & Alexandre V. Latchininsky
Department of Renewable Resource, University of Wyoming, Laramie, WY 82071

Grasshoppers compete directly with cattle for available rangeland forage. They consume roughly 25% of prairie vegetation in 17 western U.S. states at a cost of $900 million/yr. Horn flies [*Haematobia irritans* (L.)] have been a major pest to cattle in the United States since the mid 1880s. Infestations cost the industry close to $1 billion/yr through control costs and production losses. Dimilin 2L, an insect growth regulator (a.i. diflubenzuron), inhibits immature insects from properly molting and has been used successfully in controlling nymphal grasshopper outbreaks. We are examining the secondary effects of Dimilin applied for grasshopper control on horn flies. We hypothesize that, after feeding on Dimilin-treated vegetation, the insecticide would pass through the cows' digestive tract and affect the horn fly larvae that develop in the dung. Our observations from 2008 and 2009 indicate that Dimilin decreases the numbers of horn flies emerging from dung deposited in the areas treated with the insecticide compared to untreated rangeland.

33P
DANCING IN THE DARK: DOES COURTSHIP COMPLEXITY INCREASE WITH EVOLUTIONARY TIME?

David A. Tanner and James P. Pitts
Utah State University, 5305 Old Main Hill, Logan UT, 84322

Since Darwin, students of evolution have offered conjecture and contrivances to explain the evolutionary history of morphological and behavioral characters within a taxon. A common unifying theme among explanations of evolutionary histories is an increase in complexity, particularly within behavioral cascades. Indeed, the current proposed phylogeny of the eulophid wasp *Melittobia* is founded on the assumption that the most basal species has a male courtship display that is similar to the rest of the Tetrastichinae, while the more derived species have sequentially evolved more complicated behaviors. To test how male courtship display has evolved in *Melittobia*, we created a molecular phylogeny of the genus using Bayesian techniques based on the genes ITS1, ITS2, and CO1. On this phylogeny we mapped eight characteristic behaviors associated with courtship using character mapping software. We show that, contrary to the previously proposed morphological/behavioral hypothesis, the evolution of courtship display in *Melittobia* does not follow a trend of increasing complexity, and we suggest that other *scala naturae* type behavioral hypotheses be reassessed.

10-MINUTE STUDENT PAPER COMPETITION
UNDERGRADUATE PAPERS

34SP
SURVEY OF RHIZOSPHERE COMPETENT ENTOMOPATHOGENIC FUNGI ON SMALL FRUITS AND CHRISTMAS TREES IN THE WILLAMETTE VALLEY, OR

Joanna Fisher[1], Denny J. Bruck[2]

[1]Oregon State University, Bioresource Research Program, Corvallis OR 97330
[2]USDA ARS Horticultural Research Unit, 3420 NW Orchard Avenue
Corvallis, OR 97330

The entomopathogenic fungi *Metarhizium anisopliae* and *Beauveria bassiana* are commercially available as microbial control agents for the black vine weevil, *Otiorhynchus sulcatus* (F.) (Coleoptera: Curculionidae), the key root-feeding insect pest in Pacific Northwest small fruits and ornamentals. Understanding habitat selection is critical to improving the efficacy, persistence and cost of these fungi as microbial insecticides. This study sought to determine the prevalence of *Metarhizium* and *Beauveria* in the rhizosphere of host plants collected from the Willamette Valley of Oregon. Entomopathogenic fungi were isolated from the rhizosphere of strawberry, blueberry, grape and Christmas trees and assigned to species based on genetic analysis. Four species of *Metarhizium* were found. Strawberries and Christmas trees had the largest percentage of plants colonized and the greatest fungal diversity. Strawberries and blueberries were significantly more likely to be associated with *M. brunneum* and Christmas trees with *M. guizhoense* and *M. robertsii.* Grapes had no significant association with any of the *Metarhizium* species. Bioassays are underway to determine the pathogenicity of each species to *O. sulcatus*. This is the first study to survey fungal rhizosphere interactions and to sample *Metarhizium* species diversity and prevalence in agricultural field conditions. This study suggests that certain species of *Metarhizium* are associated with the strawberry, blueberry and Christmas tree rhizosphere and could potentially provide better pest control for *O. sulcatus*.

10-MINUTE STUDENT PAPER COMPETITION
PhD PAPERS

35SP
EFFECTS OF INSECTICIDES ON POTATO PSYLLID (HEMIPTERA: PSYLLIDAE) BEHAVIOR

Casey D. Butler, Frank J. Byrne and John T. Trumble

Department of Entomology, University of California, Riverside, CA

The potato psyllid, *Bactericera cockerelli* (Sulc) (Hemiptera: Psyllidae), is a serious pest of potatoes in Central and North America. The potato psyllid causes yield loss by directly feeding on crop plants and by vectoring bacterial pathogens such as *Candidatus* Liberibacter *psyllarosus* (a.k.a. Cn. L. *solanacearum*) which causes "zebra chip" (ZC) disease in potatoes (characterized by a pattern of necrosis that is evident when infected tubers are fried). Current pest management practices rely on the use of insecticides to control the potato psyllid to lower ZC incidences and increase yields. While many studies have focused on the mortality insecticides can cause on potato psyllid populations, little is known regarding the behavioral responses of the potato psyllid to insecticides. Thus, the objectives of this study were to determine the effects of insecticides on adult potato psyllid behaviors and the residual effects of insecticides on potato psyllid behaviors over time. Insecticides tested included imidacloprid, kaolin particle film, horticultural spray oil, abamectin, and pymetrozine. All insecticides significantly reduced feeding durations and significantly increased the abandonment of potato leaflets. Nonfeeding behaviors such as tasting, resting, and cleaning exhibited variable relationships with insecticide treatments over time. These data will provide information for the selection of insecticides used in an integrated pest management program for potato psyllid control.

36SP
BEHAVIORAL RESPONSE OF THE PREDATORY MITE *TYPHLODROMUS PYRI* (ACARI: PHYTOSEIID) TO METHYL SALICYLATE

Angela N. Gadino[1], Vaughn M. Walton[1], Jana Lee[2]

[1]Department of Horticulture, Oregon State University, Corvallis, OR, 97331-7304
[2]USDA-ARS Crops Research Laboratory, 3420 NW Orchard Ave., Corvallis OR 97330

The herbivore induced plant volatile methyl salicylate (MeSA) is believed to play an important role in predatory mite foraging behavior and prey location. An infested plants ability to attract and retain predatory mites as a defense mechanism is integral to successful pest mite biological control. In recent years Pacific vineyards have experienced increases in damaging outbreaks of the grape rust mite *Calepitrimerus vitis* (Nalepa). Although MeSA occurs naturally in the volatile blend released by infested grape leaves, it is hypothesized that artificially dispensing additional MeSA may be a novel management tool employed to attract predators toward rust mite outbreaks.

In this study, the behavioral response of *Typhlodromus pyri*, a key predator of *C. vitis*, to MeSA was tested using a Y-tube olfactometer in laboratory bioassays. Satiated adult female mites were tested using MeSA diluted in hexane at six doses ranging from 200 to 0.002µg. A hexane-only control was included and individual mite choice (MeSA or hexane) recorded after each run. Results displayed significantly higher proportions of *T. pyri* preferred MeSA compared to hexane-only at doses 0.02 ($P = 0.007$), 0.2 ($P < 0.001$), and 20µg ($P < 0.001$). There were no differences in choice detected at the highest (200µg) and lowest (0.002µg) doses. The dose-response relationship was marginally significant ($P = 0.054$) suggesting that *T. pryi* attraction to MeSA may be dose dependant. These results indicate that using MeSA lures may be an effective strategy to increase predatory arthropod populations in vineyards however additional field experiments are necessary.

37SP
BIRD CHERRY-OAT APHID BEHAVIOR IN RESPONSE TO BARLEY YELLOW DWARF VIRUS DISEASE PROGRESSION

Laura L. Ingwell, Nilsa A. Bosque-Pérez, Lana M. Unger, Honjian Ding, Alexander V. Karasev, Robert S. Zemetra, Sanford D. Eigenbrode

Department of Plant, Soil and Entomological Sciences, P.O. Box 442339, University of Idaho, Moscow, ID 83844-2339

Barley yellow dwarf virus (BYDV) causes an economically important disease of cereals worldwide. The bird-cherry oat aphid (BCOA), *Rhopalosiphum padi* (L.), is an important vector of BYDV on wheat. To manage this important disease, a better understanding of plant-virus-vector interactions is needed. Recent research has shown that BCOA prefers virus-infected compared to non-infected plants and that plant volatile cues mediate such responses. The objective of this study was to examine for the first time the influence of BYDV disease progression on BCOA behavioral responses. Assays were conducted with two wheat genotypes, virus-susceptible Lambert and a BYDV-resistant, Lambert-derived transgenic (103.1J) that expresses the BYDV coat protein. All treatments were planted simultaneously and plants were either sham- or BYDV-inoculated at 2, 3, 4 or 5 weeks after planting. Sham-inoculated plants were challenged with nonviruliferous aphids as a control for effects induced by aphid feeding alone. Choice-test bioassays were conducted 7 weeks after planting to examine preference of nonviruliferous, apterous BCOA among treatments. Leaves still attached to plants were placed in contact with a platform from which aphids could move onto the leaves. A single platform included 4 treatments, BYDV- or sham-inoculated Lambert or 103.1J, and 4 platforms (one for each of the disease progression stages) were tested simultaneously. Thirty aphids were placed in the center of each platform and numbers settling onto plants were recorded every 15 min for 2 hours. The bioassay allows detection of short-term effects likely due to olfactory, visual, tactile and gustatory host cues. The experiment was replicated 6 times. Headspace volatiles were collected to examine relationships between disease progression, virus-induced volatiles and BCOA preference. ELISA tests were performed to determine virus titer. Results will be presented and potential epidemiological implications discussed.

38SP
RESPONSE OF BEE POLLINATORS TO WILDFIRE IN SAGEBRUSH STEPPE

Byron Love, Jim Cane

Bee Biology & Systematics Lab, Utah State University, 5310 Old Main Hill, Logan, UT

Great Basin rangelands have been severely degraded by human disturbances including excessive livestock grazing, the introduction of exotic and invasive grasses, and changing weather patterns. As a result, fire frequencies and intensities have increased dramatically during the past decades, perpetuating the downward ecological spiral of destructive fire and weeds. As part of a landscape-level approach to post-fire rehabilitation, land managers have been working to include native forbs in reseeding mixtures to increase habitat diversity and resist the spread of noxious weeds. Successful establishment of native forbs requires the presence of bee communities in post-fire habitats to provide pollination services. Understanding the response of bees to wildfire is therefore an important part of Great Basin rehabilitation efforts.

This study investigates the bee guilds sampled from a 15-year chronosequence of past large wildfire sites across sage-steppe habitats in the Great Basin. Paired plots were established far into the burn (>100 meters) and outside the burn to compare the following habitat characteristics: bee density in patches of target flowering hosts (primarily *Balsamorhiza* species); the richness and similarity of bee communities; and the diversity, and density, of forbs and shrubs. Preliminary results indicate that any and all life stages of most ground-nesting wild bees will escape injury from wildfire. Furthermore, in relatively mild burns of intact sage-steppe plant communities, entire bee communities exhibit excellent prospects for survival. However, where forbs do not bloom in the year following fire (especially in previously depauperate communities or hotter fires), surviving bee communities will need supplemental forage that blooms reliably the year after seeding.

39SP
INSECT COMMUNITIES OF PACIFIC NORTHWEST HYBRID POPLARS AND ADJACENT NATURAL AREAS

R. Andrew Rodstrom, John J. Brown, John Stark and Emma Smith

Washington State University, Department of Entomology, Pullman, WA

Irrigated Inland Northwest poplars represent a unique agroforestry ecosystem as a short-rotation woody crop on a 15-year rotation. This multi-use crop is grown in Oregon and Washington under the stringent guidelines of the Forest Stewardship Council (FSC). The emphasis FSC places on environmental quality and the limitation of evaluating management decisions only after several years puts a premium on understanding the hybrid poplar ecosystem, specifically the insect community. Terrestrial arthropod communities were surveyed in pre- and post-harvest stands as well as in nearby riparian and sagebrush areas. Temperature data was also recorded both above and below ground in these communities to try and quantify potential abiotic differences between the communities. We hypothesized that epigeal arthropod community composition, based on the

Shannon-Weiner diversity index, of newly planted stands would more closely resemble sagebrush, while mature stands would be more similar to riparian areas. Surveys have indicated that the insect communities varied with poplar stand age, and that pestiferous and beneficial insects were present in all stands. Our findings suggest insect diversity is higher in first-year stands (H'=2.44±0.28) than mature stands (H'=0.82±0.23), and that the first-year and pole plantings (H'=2.36±0.25) are more similar to the natural areas (Sage H'=2.30±0.28 and Riparian H'=2.520.82±0.23). Overall the most common species were present in all communities, with *Tetramorium caespitum* dominating each community. We also show that temperatures in communities with similar physical structure closely resemble each other. These results indicate that hybrid poplar plantations support arthropod communities similar to those found in the surrounding natural habitats.

40SP

AGRICULTURAL LAND USE AND CONSERVATION EASEMENT EFFECTS ON MACROINVERTEBRATE COMMUNITY STRUCTURE IN AN ARID-LAND RIVER

Melissa A. Scherr[1], David E. Wooster[2], Sujaya Rao[1]

[1]Oregon State University Department of Crop and Soil Science, 3017 ALS, Corvallis OR
[2]Oregon State University, Hermiston Ag Research and Extension Center, PO Box 105, Hermiston OR

Located in eastern Oregon, the Umatilla River drains a watershed dominated by agriculture, and as a result the river channel and the adjacent landscape have been strongly altered. In this study, macroinvertebrates were collected from riverine habitats associated with three different types of adjacent land use: "test" sites adjacent to heavy agricultural use, "reference" sites that were relatively un-affected by agriculture, and easement sites with remedial riparian buffer zones. Macroinvertebrate communities and environmental variables were compared between these habitat types to determine the impacts of land use on the benthic aquatic assemblage. Several of the environmental characteristics of reference and test sites were significantly different (turbidity, depth, wetted width, proximity to disturbance); these environmental differences were reflected by significant differences in the macroinvertebrate communities. Comparing the communities in easement sites to the communities found in reference and test sites showed the predicted intermediate response in the lower river but not in the upper river. Rate and direction of community succession were also compared between the site types, and results indicated that the direction of community change reflected the relationships of the site types found by comparing assemblage, but that the rate of change was variable by site type with longevity of the established management regime in the adjacent landscape. Greater understanding of the effects of land management and restoration techniques on aquatic biota, with long-term biomonitoring of management regimes, is necessary for the protection of freshwater systems.

41SP

DEVELOPING A MOUSE MODEL TO DETERMINE THE EFFECT OF SAND FLY SALIVA ON THE VISCERALIZATION OF *LEISHMANIA CHAGASI*

Melody Schmid[1], Claudio Meneses[2], Dia-Eldin Elnaiem[2], and Greg Lanzaro[3]

[1]Department of Entomology, University of California – Davis, Davis, CA
[2] Vector Molecular Biology Unit, Laboratory of Malaria and Vector Research, National Institute of Allergy and Infectious Diseases, National Institutes of Health, 12735 Twinbrook Parkway, Rockville, MD
[3]School of Veterinary Medicine, Department of Pathology, Microbiology and Immunology, University of California – Davis, Davis, CA

Visceral Leishmaniasis (VL) is a vector borne disease that affects some of the world's poorest populations. In the New World VL is caused by the parasite *Leishmania chagasi*, which is transmitted by the sand fly *Lutzomyia longipalpis*. Sand fly saliva is known to have anti-hemostatic effects and immunomodulatory activities, which likely account for its ability to enhance cutaneous infections in BALB/c mice. These observations led us to hypothesize that sand fly saliva promotes the visceralization of *L. chagasi*. Indeed, preliminary data obtained using hamster hosts showed that the saliva of different populations of *Lu. longipalpis* have different effects on the visceralization of *L. chagasi*. However, the hamster model is limited because of the unavailability of immunological reagents, and the BALB/c mouse model is unsuitable because it clears the visceral infection. The objectives of this study are to develop a natural mouse model for VL that can be used to determine the effect of sand fly saliva on the visceralization of *L. chagasi*. We infected eight strains of mice (C57Bl/6, BALB/c, CD1, C3H, NuNu, NIH III, SCID Beige, and NOD SCID) via intraperitoneal injections of *L. chagasi* obtained from hamsters. Three strains (NuNu, NIHIII, and SCID Beige) showed signs of visceral disease up to sixteen weeks following injection, with typical parasite loads of 10^3 parasites per 100 host cells in the liver and spleen. Parasites isolated from the mouse spleens were then injected into naïve mice intradermally with sand fly saliva. The presence of parasites in the spleens of these mice supports the optimization of these strains as mouse models of VL. If sand fly salivary components prove to play an important role in visceralization they could be promising targets for a transmission blocking vaccine that could be integrated with current control methods.

42SP

NO FOOD, NO BROOD: UNIQUE LARVAL EJECTION BEHAVIOR IN A NATIVE BUMBLE BEE COLONY

Kimberly M. Skyrm, Sujaya Rao, William P. Stephen

Oregon State University, Department of Crop and Soil Science, 3017 ALS, Corvallis, OR.

Bumble bees (*Bombus* spp.) are key social insect pollinators in native and agricultural ecosystems. Colonies require continuous access to food resources to fulfill the dietary needs of developing larvae. When food is scarce, workers are known to eject larvae; however, specific impacts of pollen (protein source) and nectar (carbohydrate source) availability on larval ejection behavior are unknown. The objective of this study was to determine the effects of both pollen and nectar abundance on larval ejection behavior in colonies of the native bumble bee, *Bombus vosnesenskii*. In separate pollen and nectar experiments, colonies reared from wild queens were assigned to four treatments (none, low, standard, high) using a randomized block design with five replications. Daily observations were made on the quantity of pollen and nectar consumed in each experiment, and on the number of larvae ejected from each colony. Analysis of variance indicated a significant decrease in larval ejection as the quantity of pollen presented to colonies increased ($P = 0.027$); no such correlation was observed in the nectar experiment ($P = 0.464$). In contrast, the number of dead larvae within the nest was significantly higher both in colonies exposed to 'no pollen' ($P = 0.040$) and 'no nectar' ($P < 0.001$) compared to the other treatments. Differential use of pollen and nectar resources within bumble bee nests, and the correlation between the unique larval ejection behavior that bumble bees engage in for maintenance of nest hygiene and the presence of workers, will be discussed.

43SP

NATURAL ENEMY RESPONSES TO VARIOUS RATIOS OF APHID SEX PHEROMONE COMPONENTS IN PRUNE ORCHARDS

Emily J. Symmes and Frank G. Zalom

Department of Entomology, University of California, Davis CA 95616 USA

A number of natural enemies have been shown to use host-produced sex pheromones as kairomones to facilitate host location, predation, and parasitism. The objective of the current study was to determine the attraction and specificity of aphid natural enemies (green lacewings and parasitoids) to different blends of the aphid sex pheromone components (*4aS, 7S, 7aR*)-nepetalactone and (*1R, 4aS, 7S, 7aR*)-nepetalactol. Experiments were conducted in four prune orchards in California, two located in Yolo County and two in Sutter County, during the fall of 2008. Water traps, positioned in the tree canopy, were baited with one of seven aphid sex pheromone blends or a no-pheromone control. The following neptalactone:nepetalactol ratios were included in the experiment: 1:0, 0:1, 1:1, 2.6:1, 3.4:1, 5:1, 7:1, and 0:0 (no-pheromone control). Green lacewing adults and parasitoids in each trap were counted weekly and compared among treatments. The results of this study will be presented and biological and management implications discussed.

44SP

RAPID EVOLUTION OF THE BIOLOGICAL CONTROL AGENT *LONGITARSUS JACOBAEAE* (COLEOPTERA: CHRYSOMELIDAE)

Marianna Szűcs, Mark Schwarzländer

Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844

Biocontrol introductions provide excellent opportunities to study microevolutionary processes since the time of release of an exotic organism to a new environment is usually precisely known. Rapid adaptations can take place especially in insect populations with short generation times following introduction. The ragwort flea beetle (*Longitarus jacobaeae* Waterhouse) was introduced in 1968 from Italy to the western coastal states of the U.S. to control the invasive tansy ragwort (*Senecio jacobaea* L.). Following readily establishment in coastal habitats, Italian beetles collected in Salem, OR were moved to higher elevation tansy ragwort infestations at Mt. Hood, OR from 1978 onwards, where soon changes in the beetles' life history traits were observed. We conducted reciprocal transplant experiments and reared *L. jacobaeae* biotypes in a common laboratory environment to separate heritable from environmental effects on life history traits. Our results indicate that the Mt. Hood population of *L. jacobaeae* underwent genetically based life history changes in less than 30 years following exposure to a high elevation climatic regime.

45SP

MIMICRY CONFUSES TAXONOMY: LESSONS FROM THE *DASYMUTILLA BIOCULATA* SPECIES-GROUP (HYMENOPTERA: MUTILLIDAE)

Kevin A. Williams, Carol D. von Dohlen and James P. Pitts

Department of Biology, Utah State University, 5305 Old Main Hill, Logan, UT 84322.

This study scrutinizes the validity of the ten species and four subspecies comprising the *Dasymutilla bioculata* species-group. Five lines of evidence are examined: morphological data derived from both sexes, behavior data derived from study of mating pairs, host identity, geographic distribution, and molecular data derived from the internal transcribed spacers 1 and 2 (ITS1 and ITS2). We conclude that *D. bimaculata*, *D. chiron, D. chiron ursula, D. creusa, D. creusa bellona, D. medea, D. lepeletierii, D. melanippe, D. melanippe conformis, D. praegrandis, D. praegrandis russata, D. pyrrhus,* and *D. sulcatulla* are all **junior synonyms** of *D. bioculata.* Color variation, caused by Müllerian mimicry, is the main cause of this over-splitting.

46SP

HOW DID CALIFORNIA'S GEOLOGIC HISTORY AFFECT VELVET ANTS (HYMENOPTERA: MUTILLIDAE)?

Joseph S. Wilson and James P. Pitts

Department of Biology, Utah State University, 5305 Old Main Hill, Logan, UT 84322

While several arid-adapted taxa live in the Central Valley of California, it is unclear how these species are related to species inhabiting the Nearctic deserts. We investigate the historical biogeographical patterns within and among species of the *Sphaeropthalma unicolor* species-complex (Hymenoptera: Mutillidae) to explore the relationship between the arid-adapted taxa in the mesic Central Valley of California and the surrounding deserts. Phylogenetic relationships were determined by analyzing the two rDNA internal transcribed spacers (ITS1 and ITS2) with Bayesian techniques. Divergence dates were estimated for major nodes using two different molecular dating analyses. Ecological niche models were developed using Maxent 3.3.1. These models where projected on Last Glacial Maximum (~22,000 years BP) climatic reconstructions and Last Interglacial (~120,000 - 140,000 years BP) climatic reconstructions. The phylogenetic reconstruction shows each of the three species in the *S. unicolor* species-complex forming a distinct, well-supported clade. Both molecular dating analyses resulted in similar dates, with the split between *S. angulifera* and the other two species occurring in the late Neogene and the split between *S. unicolor* and *S. mendica* occurring in the early Pleistocene. Ecological Niche Models for each species were significantly better than random. These models suggest that the glacial and interglacial cycles caused expansion and contraction of suitable habitat for each species during the Pleistocene. Both late Neogene and early Pleistocene events were influential in the diversification of the *S. unicolor* species-complex, but Pleistocene climatic fluctuations were responsible for the split between the Mediterranean-adapted species and the desert-adapted species.

47SP

STUDY ON *AEDES AEGYPTI* ODORANT BINDING PROTEIN-1

Ney Ribeiro Leite[1], Wei Xu[2] (student presenter), Yuko Ishida[2], Jorge Iulek[3], Renata Krogh[1], Walter S. Leal[2], Glaucius Oliva[1]

Centro de Biotecnologia Molecular Estrutural, Instituto de Física de São Carlos, Universidade de São Paulo, São Carlos, São Paulo, Brazil
Department of Entomology, University of California Davis, Davis, California, United States of America
Departamento de Química, Universidade Estadual de Ponta Grossa, Ponta Grossa, Paraná, Brazil

Olfaction is essential in guiding mosquito host-seeking behaviors. Odorant binding proteins (OBPs) are highly accumulated in sensillar lymph and involved in the transport of odorants to the receptors. *Aedes aegypti* odorant binding protein-1 (AaegOBP1) is the first OBP identified from antennae of mosquito *A. aegypti*, a major vector of human diseases such as dengue and yellow fever. In this study, recombinant AaegOBP1 was expressed in *Escherichia coli* and purified by Fast Protein Liquid Chromatography (FPLC) with ion-exchange and gel-filtration columns. The purified protein was analyzed circular dichroism (CD) as well as X-Ray crystallization for structural analysis. Like other OBPs, AaegOBP1 was found the pH dependent conformational change by CD spectrum. The structure of AaegOBP1 shares the common fold of insect OBPs with six a-helices knitted by three disulfide bonds. Cold binding assay result showed that AaegOBP1 binds to nonanal, one compound identified from human skin volatile, leading to the assumption that AaegOBP1 plays an important role in the detection of nonanal in adult females.

48SP

THE EFFECTIVENESS OF ENTOMOPATHOGENIC FUNGI AND *BACILLUS THURINGIENSIS* AGAINST AVOCADO THRIPS IN THE LABORATORY

Deane K. Zahn and Joseph G. Morse

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

Avocado thrips, *Scirtothrips perseae* Nakahara, is a recently invasive pest of California avocados. Effective alternatives to traditional pesticides are desirable to reduce impacts on natural enemies and broaden control options in an effort to minimize pesticide resistance via rotation of control materials. We evaluated *Bacillus thuringiensis* (*Bt*) proteins Cyt 1Aa and Cyt 11Aa in two forms, (activated and inactivated) and multiple strains of *Beauveria bassiana* (Balsamo) against Avocado thrips. The six *B. bassiana* strains were tested at four concentrations and log-probit analysis generated LC_{50} and LC_{95} values but χ^2 analyses did not result in any significant differences between any of the strains. However, the performance between strains can be rated based upon the LC_{50} and relative linearity of the response line. Neither activated or inactivated forms of either *Bt* proteins (Cyt 1Aa and Cyt 11Aa) resulted in thrips mortality. Further results for the two *Bt* proteins and the six *B. bassiana* strains will be discussed.

SYMPOSIUM: INVESTIGATING THE CONNECTIONS BETWEEN IPM AND WATER QUALITY

49
THE ROLE OF IPM IN WATER QUALITY—AGENCY PERSPECTIVE

Bob Nowierski, USDA National Institute of Food and Agriculture (NIFA)

50
PESTICIDES: DO THEY HAVE A NEGATIVE EFFECT ON AQUATIC ECOSYSTEMS?

John Stark, Washington State University, Puyallup, WA

Even though IPM has been implemented in many crop systems, pesticides are still entering surface waters in the United States. Pesticides are usually found at low concentrations but as mixtures in almost even surface water systems in the country. An important questions is: are pesticide mixtures at the concentrations found in the environment causing damage to aquatic organisms? In this talk, several case studies will be presented to answer this question.

51
TARGETING ADOPTION OF BMPS TO FARMLANDS ADJACENT TO IMPAIRED WATERWAYS USING GIS MAPPING AND GROWER VISITS

Parry Klassen, East San Joaquin Water Quality Coalition/Coalition for Urban Rural Environmental Stewardship (CURES), Modesto, CA

Central Valley watershed coalitions are responsible for identifying sources of farm inputs in surface water then encouraging growers to adopt BMPs should their practices lead to impairments of water quality. Water sampling by the East San Joaquin Water Quality Coalition (ESJWQC) since 2005 identified 22 waterways in the region with exceedances likely caused by farm inputs.

The ESJWQC in 2009 used a prioritization process to work with its members. Three waterways with the highest frequency of pesticide exceedances were selected for a outreach. GIS mapping identified coalition parcels adjacent to the priority waterways. Pesticide Use Reports were examined to determine if members used pesticides found in sampling. Coalition representatives visited 100% of their members along the priority waterways. Discussed were their existing farming practices and BMPs for mitigating potential problems. Water sampling in the priority watersheds between March 2009 and August 2009 found only one exceedance of the targeted pesticide.

52
EFFECT OF RIPARIAN VEGETATION ON SURFACE WATER LOADING OF GROUND AND AERIALLY-APPLIED PESTICIDES IN CHERRY PRODUCTION

Jeffrey J. Jenkins[1, 2], Kelly Wallis[2], Phillip K. Janney[1], Helmut Riedl[2, 1]

[1]Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR,
[2]Mid Columbia Agricultural Research and Extension Center, Oregon State University, Hood River, OR

We evaluated the effectiveness of adapted and native woody plant species as drift barriers between cherry orchards and surface water at two sites in Wasco County, Oregon. Spray deposition samplers consisted of filter paper attached to rectangular aluminum frames positioned at 5m above the ground. Five samplers were located along two transects (one intercepted by riparian vegetation) extending from within the orchard towards the creek. Application of malathion ULV was by fixed-wing aircraft. Ground application by tower or standard airblast sprayer used a fluorescent dye as a tracer. Wind speed and direction, and temperature were monitored. In 2006 and 2007 delayed dormant and late season ground applications were evaluated. During June, 2007 two aerial applications at each site were evaluated. Areas without riparian vegetation resulted in higher stream loading estimates. Estimated malathion stream concentrations were compared to adverse effects data for aquatic species.

53
APPROACHES AND TOOLS FOR EFFECTIVE WATER QUALITY MONITORING PROGRAMS: FOCUS ON BMP ASSESSMENT FOR STREAM SYSTEMS

Ginger Paige, University of Wyoming; Nancy Mesner, Utah State University

Effective water quality monitoring programs require that careful thought and consideration be given to collecting quality data that will meet the specific monitoring objectives. This is especially true if the objectives change from monitoring for 'compliance' to monitoring for assessing the effectiveness of a BMP that has been implemented. A new guidance document and associated tools and approaches have been developed to assist water quality monitors in developing 'effective' monitoring programs. The target audience, for these tools, is federal and state agencies that conduct or use water quality monitoring data as well as anyone actively involved with water quality monitoring programs.

54
IPM CASE STUDY IN CALIFORNIA ALMOND PRODUCTION

Frank Zalom, University of California, Davis, CA

55
THE SOCIAL SCIENCE BEHIND WATER QUALITY PROGRAMMING

Bob Mahler, University of Idaho, Moscow, ID

SYMPOSIUM: NEW DIRECTIONS IN IPM FOR STRUCTURAL, VETERINARY, AND PUBLIC HEALTH PESTS

56
THE SACRAMENTO-YOLO MOSQUITO & VECTOR CONTROL DISTRICT'S EVOLVING INTEGRATED PEST MANAGEMENT PROGRAM

Marcia Reed
Sacramento-Yolo Mosquito & Vector Control District, 8631 Bond Road, Elk Grove, CA

The Sacramento-Yolo Mosquito & Vector Control District's mission is to provide safe, effective and economical mosquito and vector control. To accomplish this, we provide ongoing surveillance of mosquitoes and other vectors to determine the threat of disease transmission and lower annoyance levels. As a District, we promote cooperation and communication with property owners, residents, social and political groups, as well as other governmental agencies to help in these efforts. This presentation will focus on the execution of the District's IPM program in response to ever changing parameters: West Nile Virus, the declining housing market, public outcry over adulticiding applications and the upcoming National Pollutant Discharge Elimination System permit. The District has reacted to these challenges by incorporating new and evolving strategies, including aerial surveillance of abandoned swimming pools, enhanced public education and outreach through diverse media outlets, and the monitoring of resistance in the mosquito population in Sacramento and Yolo counties.

57
CONTROLLING YELLOWJACKETS IN SOUTHERN CALIFORNIA

Michael K. Rust, Richard S. Vetter and Donald A. Reierson
Department of Entomology, University of California, Riverside, CA 92521

We researched control of the western yellowjacket, *Vespula pensylvanica*, in southern California with baiting as part of a potential IPM strategy. The premise is that foragers take tainted meat back to their colony to feed the larvae with the result that the entire colony is killed. The bait needs to have delayed toxicity so that it doesn't kill foragers too quickly before they have a chance to make multiple trips between the colony and bait station. Fipronil (0.25%) mixed with cooked canned chicken works very well in this regard as an effective toxicant at low dose. We tested other compounds to determine if alternates could be found. Dinotefuron (0.05%, 0.025%, or 0.0125%) decreased populations 50% to 75% in the first week after deployment, but wasp populations recovered to levels similar to that of the control within 1 or 2 weeks. Chlorfenapyr (0.05%) reduced the number of foragers by 18 to 28% for 2 weeks, but control was not nearly as effective as fipronil.

Using a novel IPM technique, we attempted virtual baiting in which wasps entered heptyl butyrate-baited traps that lacked collection jars but contained a strip of cardboard treated with fipronil. In theory, the wasp enters the trap, flies around inside, contacts the treated cardboard, becomes contaminated with transferrable insecticide in the process, and eventually flies out of

the entrance holes in the trap. The wasps eventually fly back to their nest and transfer fipronil to nestmates, reducing nest population. In field tests, virtual baiting caused a 44% reduction in subsequent trap catch compared to controls after 3 weeks but not nearly as large as with the most successful toxic meat baiting. This novel technique could offer interesting promise because of the reduction of environmental contamination with toxicants.

58
ESTIMATION OF HORN FLY ABUNDANCE WITH DIGITAL PHOTOGRAPHY

Holly Ferguson, Doug Walsh, and Sally O'Neal

Washington State University, Irrigated Agriculture Research & Extension Center
24106 N. Bunn Road, Prosser, WA

Horn fly is a key pest of pastured beef cattle. Annual U.S. production losses due to horn flies are estimated to be around $800 million. Horn fly biting stresses cattle, leading to reduced calf weight gain and milk production. An accurate means of estimating fly populations is important, as pest population helps determine pest management strategies. The standard method for estimating fly populations on cattle is to visually count the flies on 10 to 15 animals in the herd. However, the accuracy of fly population estimates obtained through direct visual counts is questionable because flies and animals are constantly moving. In 2008 and 2009, we used digital photography to estimate horn fly abundance. Images of the sides and faces of bovines were captured and processed in Microsoft® PowerPoint software. A 2.5 cm^2 grid was constructed and laid over side photos to facilitate counting of flies. Because numbers of horn flies often exceeded 1,000 on a single image, regression models were devised to reduce counting time. Several of the regressions were quite good ($r^2 > 0.70$), indicating that the number of flies in a few squares of the grid may be used to estimate total flies on the cow's body; counting time could potentially be reduced by up to 75 percent. Development of this fly population estimation tool will continue in 2010; we anticipate that it will prove very useful for research scientists as well as cattle ranchers.

59
FIELD VALIDATION OF SUBTERRANEAN TERMITE (ISOPTERA, RHINOTERMITIDAE) CONTROL WITH RECRUIT® HD, A NEW TERMITE BAIT FROM DOW AGROSCIENCES

Mike Lees[1], Joe Eger[2], Joe DeMark[3], Jackie McKern[4], Mike Tolley[5], Marc Fisher[6], Ronda Hamm[5], Mike Melichar[5], Ellen Thoms[7]

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

Recruit® HD termite bait was evaluated in a large-scale regulatory study involving 145 structures across the country. This study is nearing completion. Elimination of termites at preventative (un-infested) structures and remedial (infested) structures is reviewed along with information on associated placebo (un-baited) structures. Bait consumption results will also be presented.

60

DO ANTI-TICK VACCINES HAVE A PLACE IN AN INTEGRATED CATTLE FEVER TICK CONTROL PROGRAM?

Glen A. Scoles[1], Reginaldo G. Bastos[2], Massaro W. Ueti[1], Felix D. Guerrero[3]
Carlos E. Suarez[1], Donald P. Knowles[1]

[1]USDA, ARS, Animal Disease Research Unit, 3003 ADBF, Washington State University, Pullman, WA
[2]Washington State University, Department of Veterinary Microbiology and Pathology, Program in Vector-Borne Disease, Pullman, WA
[3]USDA, ARS, Livestock Insects Research Laboratory, 2700 Fredricksburg Road, Kerrville, TX

The Cattle Fever Ticks, *Rhipicephalus (Boophilus) microplus* and *R. (B.) annulatus* are the vectors of *Babesia bovis* and *B. bigemina*, the etiologic agents of bovine babesiosis or Texas Cattle Fever. From as early as the 1870's through the 1930's these diseases were having a devastating effect on the US cattle industry, especially among northern cattle exposed to animals moved from southern states. Smith and Kilborne's groundbreaking discoveries and the work of Cooper Curtice in the 1890's demonstrated that the most effective means of controlling outbreaks of cattle fever would be to block transmission by eliminating their tick vectors. An eradication program was initiated and by 1943 these tick species had been driven back to a narrow quarantine zone along the Texas-Mexico border. The eradication program, and subsequent maintenance of the quarantine relied upon one of the earliest integrated pest management programs for a livestock pest and include all the classical hallmarks of an IPM strategy: acaricide treatment based on monitoring, controls on the movement of cattle, and pasture management. However ecological changes in southern Texas, coupled with the development of resistance to a broad array of acaricides have lead to incursions of these tick species into areas that have been free of infestation for >60 years. It appears that these developments will require re-evaluation of the integrated tick management paradigm that has been in use for the last 100 years.

With acaricide resistance and the failure of pasture rotation due to the presence of alternate hosts, new tools will be needed to renew and extend this well-established and historically very successful tick management program. Addition of anti-tick and/or transmission blocking vaccines to the mix of tools available for management of Cattle Fever ticks could tip the scales back in favor of control. Although an anti-tick vaccine based on a tick gut protein (Bm86), has been developed and used for control of *Boophilus* ticks in certain parts of the world (Australia, South America), the efficacy of the vaccine is limited and neither it nor any other anti-tick vaccine is currently available commercially in the US. Identification of new tick and parasite proteins that might serve as anti-tick or transmission blocking vaccine targets, coupled with the development of new systems for delivery of these antigens to continuously stimulate bovine immune responses, now make it advantageous to revisit the anti-tick vaccine strategy.

We have used a proteomics approach to identify tick genes that are expressed in the gut and ovaries in response to blood feeding and/or infection with *B. bovis.* Using bioinformatics tools, a subset of up-regulated tick genes has been selected for further study of their biological functions using RNA interference technology. Using this approach the expression of specific genes can be silenced, allowing examination of the relationship between gene expression and blood feeding success, survival, fecundity, infection with *B. bovis*, etc. Genes with important biological

functions relative to these parameters can then be targeted for additional investigations including production of monoclonal antibodies for localization of gene products and finally, leading to protection assays in cattle. Ultimately these studies will lead to identification of tick genes that can be antigenic targets for anti-tick and/or transmission blocking vaccines. In addition, combinations of antigens targeting multiple different tick tissues could create synergies that might lead to an enhanced level of protection.

In parallel to the work to identify new antigens we have developed a method to transfect *B. bovis* so that it will express foreign (i.e. tick) antigens. Attenuated strains of *B. bovis* have long been used in Australia to protect cattle against disease; if these parasite strains can be engineered to express tick antigens as well, this approach could lead to both anti-tick immunity and protection from disease. The overall goal of this work is to produce a strain of *B. bovis* that will express a novel combination of tick proteins resulting in a vaccine strain that would protect cattle against both disease and against tick infestation.

Addition of an effective anti-tick vaccine to the mix of tools available for management of cattle ticks may help to reinvigorate and strengthen the Cattle Fever Tick Eradication program. A highly effective anti-tick vaccine might even allow cattle tick eradication to be extended further to the south. As with the highly successful screwworm eradication program, movement of the quarantine line south to the Isthmus of Panama would drastically increase the long-term sustainability of the program.

61

RUNOFF OF INSECTICIDES USED FOR ANT CONTROL FROM INDIVIDUAL RESIDENCES: CORRELATING TECHNIQUE WITH RUNOFF AND EFFICACY

Les Greenberg, Michael K. Rust
Department of Entomology, University of California, Riverside, CA 92521

Insecticides are commonly used for ant control around residential homes, but post-treatment runoff may contribute to contamination of surface water in urban watersheds. This study represents the first instance where runoff of insecticides was directly measured after applications around single family residences. During 2007 houses were treated with bifenthrin or fipronil sprays following standard practices. The resulting bifenthrin runoff in the irrigation water had a mean concentration of 14.9 ppb at 1 week post-treatment and 2.5 ppb at 8 weeks, both high enough to be toxic to sensitive aquatic organisms. In comparison, treatments with bifenthrin granules resulted in no detectable concentrations in the runoff water after 8 weeks. The mean concentration for fipronil used as a perimeter spray was 4.2 ppb one week post-treatment and 0.01 ppb at 8 weeks, with the first value also suggesting a potential for causing acute aquatic toxicity to sensitive organisms. During 2008 pin stream applicators and no-spray zones were considered as management options for mitigating pesticide runoff. The pin stream perimeter application of fipronil had low insecticide runoff (mean = 0.08 ppb one day post-treatment) while providing good ant control (80% reduction). In comparison, the inclusion of a no-spray zone, although it resulted in reduced pesticide runoff (0.14 ppb for bifenthrin and 3 ppb for fipronil), was not effective for ant control. Results from this study suggest that both efficacy and runoff potential should be considered when designing pest management practices. The pin stream application merits further evaluation for its value in reducing pesticide runoff from residential homes.

62
THE ROLE OF FISH AS BIOLOGICAL CONTROL AGENTS AS PART OF INTEGRATED MOSQUITO MANAGEMENT

Jennifer A. Henke
Department of Entomology, University of California, 3401 Watkins Drive, Riverside, CA

Mosquitofish have been used for larval mosquito control for nearly 100 years. These and other non-native fish are now known to have negative impacts on the aquatic community including declines in native fish populations and non-specific feeding. More research is being conducted on the plausibility of using native fish species as biological control agents. When incorporated into integrated mosquito management (IMM) programs, the impact of pesticide residues on the fish population must also be considered. This presentation will review recent studies on the use of fish as biocontrol agents as well as our increased knowledge about their role within IMM programs.

63
POPULATION GENETICS OF THE NORTHERN FOWL MITE (*ORNITHONYSSUS SYLVIARUM*): LOOKING FOR MANAGEMENT TOOLS AMONG PATTERNS OF INFESTATION AND ADAPTATION

Jeb P. Owen[1], John McCulloch[1], Jeremiah W. Busch[2]
[1]Department of Entomology and the Center for Reproductive Biology
Washington State University, PO Box 646382, Pullman, Washington 99164 USA
[2]School of Biological Sciences and the Center for Reproductive Biology
Washington State University, PO Box 644236, Pullman, Washington 99164 USA

The northern fowl mite, (*Ornithonyssus sylviarum*; NFM) is a common and widespread ectoparasitic pest of poultry in the United States that is believed to migrate between wild and domesticated bird species. This idea has been supported by the observation of NFM on over 72 bird species, the broad geographic distribution of the mite and persistent re-occurrence of infestations. However, to date there have been no direct tests of genetic structure and gene flow among NFM populations. Using microsatellite markers (15 loci), we genotyped 321 mites from 11 populations that were collected from commercial chicken flocks in Washington, California and Georgia. In addition, we genotyped mites from two wild bird species (house finch and european starling) that were sympatric with several poultry populations in California. The mite populations were highly structured (Fst = 0.62 to 0.87), with no evidence of isolation by distance. The greatest genetic divergence occurred between mites from chickens and mites from wild birds. The effective population sizes (Ne) were similar among all populations and migration rates were low (proportion of migrants per generation ~1x10-5) among poultry and between the domesticated and wild host populations. These data contradict the prevailing idea that the northern fowl mite is frequently moving among bird populations and switching host species. This study suggests that the distribution of a cosmopolitan, generalist parasite may not reflect frequent parasite migration. Instead, these parasites may have physiological, or genetic, traits that enable adaptation to diverse selection pressures.

64

IPM AND INSECTICIDE RESISTANCE MANAGEMENT FOR HORN FLIES ON PASTURED AND RANGE CATTLE

Michael G. Fletcher

Y-TEX Corporation, 1825 Big Horn Av., Cody, WY

The horn fly, *Haematobia irritans* (Linnaeus), is the most economically important ectoparasite of pastured and range cattle in the United States. At the present time cultural and biological control methods offer only limited potential for control of horn flies compared to chemical control methods. Due to the highly dispersed nature of pasture and range cattle, insecticide impregnated ear tags make the ideal method to control this pest. Because horn flies have multiple generations per year and ear tags release their insecticide load in an inverse exponential manner horn flies have a tremendous ability to develop resistance to the insecticides in ear tags. For this reason and the limited potential of alternate strategies in many states, IPM programs for pastured cattle should center on the management of horn fly insecticide resistance. Thirty years ago the first insecticide impregnated ear tags were introduced with unprecedented control. The first tags to receive wide acceptance contained synthetic pyrethroids and provided five months control in most regions. Within three years the first evidence of product failure due to resistance started to appear in the southern United States. Within five years of their introduction horn fly resistance to pyrethroid tags had spread all across the US. Then organophosphate ear tags were developed and presented the possibility for insecticide rotation. For 25 years Y-TEX has been developing and recommending rotation programs for its customers that have reduced and/or delayed the development resistance in the horn fly populations and preserved the efficacy of its active ingredients. Y-TEX now uses three classes of insecticide impregnated ear tags (synthetic pyrethroid, organophosphate, and abamectin) in annual rotation alone with alternative control methods.

65

INSECTICIDE-TREATED NETTING FOR FILTH FLY CONTROL: EFFECT OF PHOTODECOMPOSITION ON NETTING EFFECTIVENESS

George W. Peck, Holly J. Ferguson and Douglas B. Walsh

Washington State University, Irrigated Agriculture Research & Extension Center
24106 N. Bunn Road, Prosser, WA

Insecticide-treated netting (ITN) has been used for decades to protect humans from biting flies, especially mosquitoes. Pyrethroids, which have high insecticidal activity and low mammalian toxicity, have been used on mosquito netting since the 1970s. Various ITN studies have shown that pyrethroids work by either repelling or killing nuisance insects. ITNs impregnated with long lasting pyrethroids are highly desirable because the target hosts are not directly treated with pesticide and considerably less pesticide is needed for effective control. Reduced pesticide use lowers the cost of pest control and slows the rate of insecticide resistance development, and leads to better sustainability of pest control systems. With reduction in pesticide use, there is reduced risk of harm to humans, animals, and the environment. In addition to public health applications, ITNs may be used in livestock production systems. Filth fly control is of primary importance to livestock producers. For beef cattle, this control traditionally comes in the form of ear tags, self-application dusters, spray-ons, pour-ons, and feed-throughs. All these methods have drawbacks, including development of resistance in target pests and possible detrimental effects of pesticide residues on livestock, consumers, and the environment. Western beef cattle producers need new tools to manage filth flies. Face fly (*Musca autumnalis*) is of concern as it can vector pink eye, a debilitating disease of cattle.

The overall objective of our study is to demonstrate the application of ITNs as a perimeter fly barrier around cattle corrals and pastures. We expect that face flies would alight on the netting to rest and receive a lethal dose of pyrethroid, thus reducing the local abundance of face flies over time. Prior to the field trials, we wanted to determine the longevity of several insecticides when applied to the netting and aged in the field. Netting was soaked in label concentrations of Tempo® (beta cyfluthrin), Grenade ER® (lambda cyhalothrin) and Capture® (bifenthrin) and placed in sunlight and shade conditions. Netting was sampled weekly or biweekly for 12 weeks. Laboratory bioassays of susceptible-strain face flies and house flies (*Musca domestica*) were performed using field-aged netting. Sub-samples of aged netting were analyzed for pyrethroid residue using a gas chromatograph with micro-electron capture detection. We will discuss the significance of this preliminary work on our future plans to deploy ITNs as perimeter barrier treatments in beef cattle corrals and pastures.

SYMPOSIUM: PROTECTING AND PRESERVING WESTERN BEE POLLINATORS

66
POLLINATORS OF PALOUSE PRAIRIE: SURVEY OF NATIVE BEE FAUNA IN A FRAGMENTED ECOSYSTEM

Timothy D. Hatten[1,2], Chris Looney[2], James P. Strange[3], Terry Griswold[3], Sanford D. Eigenbrode[2] and Nilsa A. Bosque-Pérez[2]

[1]Invertebrate Ecology Inc., Moscow, ID
[2]University of Idaho, Department of Plant, Soil and Entomological Sciences, Moscow, ID
[3]USDA-ARS Pollinating Insect Research Unit, Logan, UT

Palouse prairie once covered approximately 800,000 ha in northwest Idaho and eastern Washington. Today, perhaps less than 0.1% of the prairie remains, primarily as small remnants scattered within an agriculturally-dominated landscape. Nevertheless, the prairie is an important repository of biodiversity including a rich flora comprised of perennial grasses, forbs and woody species (including 14 rare and sensitive taxa). Bees (Hymenoptera: Apoidea) are important pollinators of Palouse prairie plants and are critical for their conservation. Unfortunately, little is known about the composition or distribution of the bee community, hindering efforts to conserve biodiversity and ecological services in this fragmented ecosystem. We sampled bees in 2002 and 2003 by pitfall trapping in five prairie remnants in Idaho (2 sites; Tomer and Paradise Ridge) and Washington (3 sites; Kramer, Smoot Hill and Rose Creek). Results from our samplings indicate that a rich bee fauna persists in Palouse prairie, comprising at least 65 species and 18 genera from five families. *Bombus* and *Osmia* were the most species-rich taxa, contributing to > 35% of all captured species. *Bombus rufocinctus* was by far the most common bumble bee species captured suggesting a selective advantage under the current landscape conditions for this native species. *Halictus* was the most abundant taxon contributing to > 75% of all captured individuals. We detected differences in community composition and abundance among remnants. For example, *Bombus fervidus* was captured in greater numbers at Kramer than at all the other remnants combined. *B. rufocinctus* was captured more commonly at Paradise Ridge, Smoot Hill and Tomer than at Rose Creek or Kramer. This later effect may be due to the influence of soil texture or elevation on the bees, because these three remnants have granitic vs loessal soils and are found at higher elevations than the other two remnants. More bees in total were also captured in these higher elevation remnants. In contrast, the phenology of most species was similar among remnants. Generally, more individuals were captured in the first week of August than in July or September, but species differences were observed as well. These and other response patterns are discussed.

67
A BUZZWORTHY CAUSE: EVALUATING FACTORS AFFECTING NATIVE BUMBLE BEE POLLINATORS IN OREGON AGROECOSYSTEMS

Kimberly M. Skyrm, Sujaya Rao, William P. Stephen
Oregon State University, Department of Crop and Soil Science, 3017 ALS, Corvallis, OR

Bumble bees are social insects that provide valuable pollination services for both agricultural crops and native plants. Worldwide, there are concerns about declining bumble bee populations which have been attributed to reduction and fragmentation of habitats, pesticide use and competition with introduced species. However, limited information is available regarding the response of feral bumble bees to these environmental factors. While various studies have been conducted on honey bees, the results are not all applicable to bumble bees which differ from honey bees in numerous aspects including life cycle, colony size, and foraging behavior. In this presentation, lab studies and field research conducted on native bumble bees in western Oregon will be presented. The studies include: 1) Evaluation of the impacts of food resource abundance on growth and mortality within bumble bee colonies; 2) Determination of the effects of common pesticides on the mortality of bumble bees; and 3) Foraging behavior of bumble bee species in commercial red clover seed fields in the Willamette Valley. Implications of the results, and options for conservation of native bumble bees for sustainability of their valuable pollination services in cropping systems and adjacent wild habitats will be discussed.

68
THE IMPORTANCE OF ENTOMOLOGICAL COLLECTIONS IN ASSESSING THE STATUS OF THE WESTERN BUMBLE BEE *BOMBUS OCCIDENTALIS* GREENE

Jonathan B. Koch[1], James P. Strange[2], Harold Ikerd[2], Terry Griswold[2]
[1]Department of Biology, Utah State University, 5305 Old Main Hill, Logan UT 84321-5305
[2]USDA-ARS Pollinating Insect Research Unit, UMC 5310, Logan UT 84333-5310

In the past decade several species of North American bumble bees have been documented to be experiencing range contractions, localized extirpation and population declines. In the west *Bombus occidentalis* Greene is of particular concern because of its former economic importance as well as an alarming trend of decline in areas where it was once abundant. To assess the detection probabilities and collection history of *B. occidentalis* we compiled museum specimen data from multiple entomological collections across the United States. We then compared the collection history of *B. occidentalis* with two common western species, *B. bifarius* Cresson and *B. vosnesenskii* Radoszkowski. The geographic range of *B. bifarius* is very similar to *B. occidentalis* and they frequently occur together. While *B. vosnesenskii* has a restricted geographic range many museums possess collection events where all three species were captured simultaneously. Finally we constructed conservative species distribution models for all three species of bumble bees using the compiled museum data and compared our current survey efforts to the model predictions. Our data suggests that *B. occidentalis* detection has been lower in our survey efforts in comparison to the collection history of the species. Additionally, the current geographic distribution of *B. occidentalis* appears to be significantly restricted; whereas, the distributions of the two other species appear unchanged.

69
PECULIAR FACTORS ENABLE SUSTAINED MASS-PRODUCTION OF NATIVE ALKALI BEES FOR ALFALFA POLLINATION

James H. Cane
USDA-ARS Pollinating Insect Research Unit, Utah State University, Logan, UT 84322

The world's only intensively managed ground-nesting bee, the alkali bee (*Nomia melanderi*) is an excellent pollinator of alfalfa. This bee illustrates the benefits and considerable challenges to managing a ground-nesting bee for conventional agriculture. To prosper, this bee requires a combination of silty soils, salty surfaces, subirrigation, long-term dedicated nest sites and local alfalfa seed production, and coordinated safe insecticide stewardship. Across a 240 km^2 watershed in near Walla Walla WA, the 17-24 more populous aggregations were annually censused for nesting bees for 8 years. Alkali bees multiplied 9-fold to 17 million females, the largest reported metapopulation of non-social bees. Several sites have remained populous for an unprecedented 50 years. The most populous nesting bed (1.5 ha) grew to 5.3 million nesting females, at densities up to 1000 nests/m^2; it is the largest bee nesting aggregation ever recorded. Even amid intensive conventional agriculture, this native bee is sustainably multiplied to the vast numbers needed for alfalfa pollination.

70
EFFECTS OF POLLEN DIVERSITY ON HONEY BEE NUTRITION AND DEVELOPMENT

Ramesh Sagili and Carolyn Breece
Oregon State University, Corvallis, OR-97331

Pollen is the sole source of protein for honey bees and is vital for their development and survival. Large monoculture, habitat fragmentation and specialized greenhouse farming systems have restricted the choice of pollen diet in honey bees. Several studies suggest that loss of alternative habitat as a result of increasing urbanization, accompanied by loss of cropland and natural vegetation may also be affecting the nutritional status of honey bees. Every year large numbers of honey bee colonies from around the country are shipped to California for almond pollination. Commercial beekeepers also move their colonies to pollinate other specialty crops where the bees predominantly rely on a single source of pollen to fulfill their protein requirement. Very little is known about effects of single source pollen consumption for extended periods on honey bees. In the wake of significant colony losses attributed to colony collapse disorder and deteriorating honey bee health since past two decades, honey bee nutrition has attained greater importance than ever. Nutrition is the first line of defense and is the key in dealing with most of the stress factors that ultimately compromise the immune system of honey bees.

Recent studies have shown that diet diversity has an effect on immunocompetence in honey bees. Bees that received poly floral diet had increased immunocompetence levels suggesting that protein nutrition and immunity were positively correlated. We are investigating and comparing the affects of single-source pollen consumption versus multi-source pollen on honey bee nutritional status, colony growth and behavior. Preliminary results from our study indicate that treatments receiving single-source pollen for six weeks had significantly reduced hypopharyngeal gland protein content, bee mass and colony growth when compared to multi-source pollen consumption treatments.

71
HONEY BEE HEALTH

Walter S. Sheppard, Judy Wu, Matthew Smart, Tim Lawrence
Department of Entomology, Washington State University, Pullman WA 99164

Ongoing challenges faced by the beekeeping industry include parasitic mites, a number of pathogens and a new syndrome (colony collapse disorder) that was first reported widely in early 2008. Washington State University established a Colony Health Diagnostic Laboratory in Pullman WA in Spring 2008 and initiated several applied research projects related to honey bee health.

The diagnostic laboratory now handles over 2800 samples/year and provides beekeepers with data on *Varroa* mite levels (mites/100 bees), tracheal mite levels (percent of bees infested/colony) and Nosema spores counts (spores/bee). These data can be used to make management decisions to provide a more sustainable approach to parasite control.

Applied research projects underway at WSU include investigation of the sub-lethal effects of pesticides in brood comb at the colony level, the distribution and seasonality of *Nosema ceranae*, cryopreservation of honey bee semen and annual importations of honey bee semen from several Old World subspecies for breeding purposes. These projects and current published research on honey bee colony health research from other laboratories will be discussed

72
THE GREAT SUNFLOWER PROJECT: HARNESSING THE POWER OF CITIZEN SCIENCE TO ACCELERATE POLLINATOR CONSERVATION

Gretchen LeBuhn
Department of Biology, San Francisco State University, 1600 Holloway Avenue,
San Francisco, CA 94132

Data from several places around the world suggests that pollinators are disappearing which has serious implications for our food supply and ecosystem health. The Great Sunflower Project empowers people from pre-schoolers to scientists to do something about this global crisis by identifying at risk pollinator communities. Using sunflowers as a standardized measure for each site where they are planted, participants time how long it takes for five bees to visit their sunflower, creating an index of pollinator service that can be compared across localities.

When managed well, the return on investment for this type of science is potentially huge. Even a moderately successful program with 5,000 active participants could accrue 25,000 observations of bees. A wildly successful program with 60,000 active participants could accrue almost a million records in a single year. As of February 2010, the Great Sunflower Project had over 80,000 people signed up to receive seeds-creating the first social network designed to map pollinator service at either a regional or continental scale; and to gather quantitative data that is directly tied to pollinator service, rather than a correlate. Preliminary analysis of the data suggests that over 30% of the gardens participating have little or no pollinator service.

73

A NOVEL APPROACH TO FOOD SECURITY: THE XERCES SOCIETY'S SUCCESSFUL THREE TIERED STRATEGY FOR POLLINATOR CONSERVATION ON FARMS

Scott Hoffman Black

Xerces Society for Invertebrate Conservation, 4828 SE Hawthorne Boulevard, Portland OR 97215, www.xerces.org

Scott Hoffman Black will discuss a three-tiered pollinator habitat conservation strategy that melds wildlife habitat creation with the pollination needs of adjacent crop production. Despite the recognized importance of pollination services there is a growing body of evidence that suggests native pollinators may be at risk. Causes of native bee declines are difficult to pinpoint, but loss of floral diversity and habitat due to increasing urbanization, expansion of intensive agriculture, invasive plants, widespread use of pesticides, climate change and disease and parasites all may play a role. It is vitally important to develop strategies that combine the needs of crop production with pollinator habitat creation. In this talk, Scott will address how disseminating sound technical information, creating supportive policy structures, and building communities of clients interested in implementing projects will help address the needs of native crop pollinators.

10-MINUTE ORAL PAPER PRESENTATIONS, PART 2 of 2
(ADDITIONAL 10-MINUTE PAPERS #28-33)

74P
THE POTENTIAL FOR USING SPINOSAD, SPINETORAM, AND METHOXYFENOZIDE TO MANAGE *LOBESIA BOTRANA* IN THE UNITED STATES

B. Bisabri[1], A. Chloridis[2], J. Dripps[3], L. Gomez[3], V. Jacquet[4], M. Lysandrou[5], A. Martin[6], C. Mavrotas[5], E. Tescari[7], M. Torne[6]

Dow AgroSciences, Crop Protection R&D
[1]Orinda, CA, USA; [2]Thessaloniki, Greece; [3]Indianapolis, IN, USA;
[4]Saint Quentin et Yvelines, France; [5]Lavrion, Greece; [6]Madrid, Spain; [7]Padova, Italy

In the fall of 2009, the European grapevine moth (EGVM), *Lobesia botrana* (Lepidoptera: Tortricidae), was first detected in Napa Valley, California. It had previously been reported from Japan and Chile infesting crops of economic importance. EGVM feeds on the buds, flowers, leaves, and fruit of several crops, including grapes, small bushberries, caneberries, and stone fruit. In grapes, feeding damage to fruit can facilitate infection by diseases such as *Botrytis*. EGVM has the potential to significantly impact California agriculture. Although new to the US, EGVM is a well established and significant insect pest in Southern Europe, the Middle East, and Northern Africa. Products containing spinosad (Group 5 insecticide) and methoxyfenozide (Group 18 A insecticide) are currently used to control EGVM in several European and Middle Eastern countries. Spinetoram (Group 5 insecticide) has been launched in several Middle Eastern and North African countries, and is in the process of being registered in Europe. Dow AgroSciences has conducted numerous efficacy trials in several European and Middle Eastern countries where the EGVM is endemic. The results of these field trials show that spinosad, spinetoram, and methoxyfenozide are highly effective against this pest, and that Success® (EPA Reg. No. 62719-292; spinosad), Entrust® (EPA Reg No. 62719-282; spinosad), Delegate® (EPA Reg. No. 62719-541; spinetoram), and Intrepid® 2F (EPA Reg. No. 62719-442; methoxyfenozide), each have the potential to be key components of EGVM management programs in California providing two different modes of action.

75P
EVALUATION OF DOW AGROSCIENCES' NEW SULFOXIMINE INSECTICIDE TO MANAGE COTTON APHIDS

Boris A. Castro, Larry C. Walton, Melissa W. Siebert, Jamey Thomas, Ralph Lassiter, Robert Haygood, Jesse Richardson, Bo Braxton, John Richburg, Fikru Haile and Larry Godfrey[1]

Dow AgroSciences LLC, Indianapolis, IN
[1]University of California-Davis, CA

Sulfoxaflor is the first insecticide from the new sulfoximine chemical class. It was discovered by Dow AgroSciences (DAS) scientists and is proprietary DAS chemistry. This novel insecticide is active against a wide range of sap-feeding insects affecting cotton including aphids, plant bugs

(*Lygus* spp.) and whitefly species. Previous DAS and university research studies indicate that sulfoxaflor is effective at low rates and provides fast acting and extended residual control of target pests. Efficacy against cotton aphids (*Aphis gossypii* Glover) in cotton was evaluated from 2006 to 2009 in nine private and public research trials. These trials were conducted under environmental conditions of eastern and western United States (Mississippi/Louisiana and California, respectively). Trials consisted of small replicated plots with four repetitions. Plots received one or two sulfoxaflor treatments compared to one or two treatments of commercial standards and an untreated check. Applications were performed during active aphid infestations at pre-squaring and pre-bloom in eastern cotton and at squaring and boll opening in western cotton. Aphid population densities were estimated by counting numbers of live aphids in ten terminals or ten leaves per plot. Counts were conducted in the laboratory using the wash method.

Results revealed that sulfoxaflor insecticide at rates of 0.022 lb/acre and above provided superior cotton aphid control compared to dicrotophos at 0.5 lb/a; thiamethoxam at 0.05 lb/a; acetamiprid at 0.05 lb/a and flonicamid at 0.089 lb/a. Control was significant at 3 d in all trials compared to the untreated check. Two trials with extended aphid infestations demonstrated sulfoxaflor residual control for $\geq$ 20 d compared to the untreated check. Sulfoxaflor has an excellent fit in IPM programs. It will be a valuable rotational partner with other chemistries and as a tool to manage insect populations resistant to other insecticides. Registration of sulfoxaflor for U.S. cotton is anticipated in 2012.

76P
TARGETED LEPIDOPTERAN MANAGEMENT IN ALFALFA: A NEW USE PATTERN FOR INTREPID®

Marc L. Fisher, Jesse M. Richardson, Jim Mueller, Barat Bisabri, and Luis Gomez
Dow AgroSciences LLC, Indianapolis, IN

Alfalfa (*Medicago sativa* L.), one of the most prized forages world-wide, provides harborage and a food source for a wide variety of pestiferous and beneficial insects. Recently, Intrepid®, an insecticide powered by the ecdysone agonist methoxyfenozide, received approval for use in alfalfa. Methoxyfenozide provides an effective IPM compatible tool for targeted lepidopteran pest management. This presentation provides data demonstrating the effectiveness of Intrepid® for control of larval *Spodoptera praefica* (yellowstriped armyworm), *S. exigua* (beet armyworm), and *Colias eurytheme* (alfalfa caterpillar). At labeled rates, Intrepid® provided up to two weeks of residual control of targeted lepidopteran pests.

77P
EVALUATION OF MANAGEMENT PROGRAMS FOR PACIFIC SPIDER MITE IN ALMONDS IN THE SOUTHERN SAN JOAQUIN VALLEY OF CALIFORNIA

Stephanie M. Rill, David R. Haviland[1], and Bradley S. Higbee[2]

[1]University of California Cooperative Extension Kern Co, Bakersfield, CA
[2]Paramount Farming Company, Bakersfield, CA

Pacific spider mite is a significant pest of almonds in the lower San Joaquin Valley of California. If not managed properly, mite-induced defoliation can reduce both the quality and quantity of the almond crop. Growers have historically tried to prevent these losses through a two-spray program whereby abamectin is sprayed early in the season, often well before mites reach a University of California threshold, and a contact miticide is sprayed at hull split. These timings were primarily based on the need to use abamectin prior to leaf hardening in late May, the lack of effective miticides available in June, and the need to protect trees during harvest. Now, however, several newly registered miticides allow for effective treatments at any time of the year. As such this project was used to compare programs using 'preventative' abamectin treatments to those based on University thresholds. Results showed that both approaches can be very effective for season-long control of spider mites, and that one treatment per season, in combination with biological control organisms, can in certain cases be sufficient to control mites. The project also showed that University of California treatment thresholds can provide an effective measure for when miticide treatments do, and do not, need to be made.

78P
CONTROL OF *LYGUS HESPERUS* WITH DOW AGROSCIENCES' SULFOXAFLOR INSECTICIDE IN COTTON

Jesse M. Richardson[1], Boris A. Castro[1], James D. Thomas[1],
Peter C. Ellsworth[2], Larry D. Godfrey[3], and David L. Kerns[4]

[1]Dow AgroSciences LLC, Indianapolis, IN
[2]University of Arizona, Maricopa
[3]University of California, Davis
[4]Texas AgriLife Extension, Lubbock

Sulfoxaflor is the first insecticide from the new sulfoximine chemical class. It was discovered by Dow AgroSciences scientists and is proprietary chemistry. This novel insecticide is active against a wide range of sap-feeding insects including aphids, plant bugs (*Lygus* spp.) and whiteflies. Results of Dow AgroSciences and university research studies indicate that sulfoxaflor is effective at low rates and provides fast-acting and extended residual control of target pests. Efficacy against *Lygus hesperus* in cotton was evaluated in 2009 in four private and public research trials. These trials were conducted in California, Arizona and Texas. Trials consisted of small plots with four replications. Plots received one to three treatments of sulfoxaflor and

commercial standards, and included an untreated check. Insect densities were estimated by sweep net sampling, with the exception of the Texas location, where a beat cloth was utilized.

Results revealed that sulfoxaflor insecticide at rates equal to or greater than 0.045 lb a.i./acre provided excellent plant bug control, comparable to flonicamid and acephate. No significant differences in cotton yield could be detected among treatments, with the exception of the Arizona location. In that study, plots from sulfoxaflor rates equal to or greater than 0.045 lb a.i./acre yielded among the highest tested. Sulfoxaflor has an excellent fit in IPM programs and will be a valuable rotational partner with other chemistries and as a tool to manage insect populations resistant to other insecticides. Registration of sulfoxaflor for U.S cotton is anticipated in 2012.

79P
RESPONSE OF HESSIAN FLY TO A POTENTIAL NEW FUMIGANT FOR EXPORTED HAY

Victoria Y. Yokoyama[1], Sue Cambron[2], and Jeanette Muhareb[3]

[1]USDA, ARS, San Joaquin Valley Agric. Sciences Center, 9611 S. Riverbend Ave., Parlier, CA
[2]USDA, ARS, Purdue University, 901 W. State St., West Lafayette, IN
[3]Dried Fruit Association of California, 1855 S. Van Ness, Fresno, CA

Hessian fly, *Mayetiola destructor* (Say), puparia were reared on wheat seedlings at the USDA, ARS, West Lafayette and shipped to the USDA, ARS in Parlier to develop new quarantine treatments to control the potential pest in hay exported from the western states to Pacific Rim countries. A mixture of 2% phosphine (PH_3) and carbon dioxide gas was tested on puparia in basic dose-response tests. Doses were 500, 750, and 1,000 ppm for 2, 3, and 4 d exposures at 5, 10, 15, and 20°C. Survival was determined by emergence of adults from exposed puparia after ≥ 60 d. A low number of survivors occurred for all dosages and durations tested at 5, 10, and 15°C, except for 1000 ppm for 4 d at 15°C. No survivors have been detected to date (≤ 49 d) for all dosages and durations tested at 20°C. Application of phosphine in gas cylinders versus the currently used aluminum phosphide in tablets will allow rapid liberation of the toxicant shortening the fumigation period. A shorter fumigation schedule will reduce handling costs by enabling freight containers of treated hay to be expeditiously transported to ports for ocean freight to overseas markets.

80P
A NEW HOST AND OVERWINTERING SITE FOR THE MEALYBUG *TRIONYMUS HAANCHENI* MCKENZIE (HOMOPTERA: PSEUDOCOCCIDAE) IN IDAHO

Juan Manuel Alvarez[1] and Fabian Menalled[2]

[1] University of Idaho, PSES, Aberdeen Research and Extension Center, Aberdeen, ID
[2] Montana State University. Land Resources and Environmental Sciences, Bozeman, MT

Trionymus haancheni McKenzie, sometimes referred to as the Haanchen barley mealybug, was discovered for the first time in Idaho during June 2003 causing damage to a commercial barley field near Soda Springs. Since then the insect has been reported causing extensive economic damage in 12 Idaho counties, Montana, Washington and Alberta, Canada. This pest can kill plants by direct feeding on the crown and foliage and can also reduce the grain quality by producing honeydew accumulations on the grain heads that prevent grain separation at harvest.

Information about control measures is limited and no insecticides currently are registered for use against this insect. The insect overwinter in the egg stage protected inside cottony ovisacs, which are deposited in the lower part of infested plants. Once plants are harvested, the stubble remaining in the soil will harbor all insect ovisacs with the eggs that will hatch the following spring once the new crop is up or volunteer plants have germinated. The insect was thought to overwinter in the barley stubble exclusively. However, during an extensive survey for wheat stem sawfly *Cephus cinctus* Norton (Hymenoptera: Cephidae) on two wheat varieties, we found that *T. haancheni* can use the openings on the wheat stems made by the wheat steam sawfly, as an entrance point inside the stems and multiple and produce ovisacs inside them. This interaction between *T. haancheni* and *C. cinctus* may complicate management of the two insect pests.

81P
PEST STATUS OF AN EXOTIC CUTWORM, THE LARGE YELLOW UNDERWING (*Noctua pronuba)* IN IDAHO

Edward John Bechinski[1], Larry Smith[2] and Frank Merickel[1]

[1]Division of Entomology, University of Idaho, Moscow, ID
[2]Nez Perce County Extension, University of Idaho, Lewiston, ID

We observed severe but geographically limited larval infestations of a European cutworm, *Noctua pronuba* (Lepidoptera: Noctuidae), in fall-planted, direct-seeded wheat fields at Nez Perce County, Idaho, from mid-February 2009 through April 2009. Known as the large yellow underwing (LYU) for its distinctive adult moth, *Noctua pronuba* was first detected in North America during 1979 in Nova Scotia and reached the Pacific Northwest during 2002. Although LYU had been known from Idaho since May 2005, larvae were rarely encountered and never observed damaging any plant until 2009. Our report constitutes the most westward economic infestations of *Noctua pronuba* in North America and only the third occasion of reported crop damage in the three decades since first North American detection. We believe that *Noctua pronuba* is univoltine in Idaho, overwintering as mature to partially mature larvae that actively

feed from early October through winter until they pupate in the soil during May. Moth flight activity in Idaho is unusually prolonged, beginning during late May and continuing through mid-October. Given larval host range and pest biology, we speculate that fall-seeded cereals and alfalfa hay are the agronomic crops most at risk in Idaho. Short rotations with wheat and reduced tillage both likely increase probability of population increase. See the on-line University of Idaho bulletin http://www.cals.uidaho.edu/edComm/pdf/CIS/CIS1172.pdf for more information.

82P
RICE WATER WEEVIL WITHIN FIELD DISTRIBUTION IN CALIFORNIA RICE

Espino, L.

University of California Cooperative Extension, 100 Sunrise Blvd. Suite E, Colusa, CA 95973

The rice water weevil (RWW), *Lissorhoptrus oryzophilus* Kuschel, is the most important insect pest of rice in California. Current treatment recommendations for RWW control suggest applying insecticides to only 10 to 15 m adjacent to levees and field borders. Experiments were conducted to validate management guidelines and allow growers to confidently continue to limit their applications to field borders.

Studies were conducted in commercial rice fields in Colusa, Maxwell, Oroville, and Princeton in the Sacramento valley of California. At each location, plots were established 5, 30, and 60 m from one of the edges of the field within a basin. Treatments assigned to plots were insecticide application (λ-cyhalothrin applied at 33.6 g a.i./ha before flooding) and distance from the field's edge. Treated and untreated plots were separated by a 2.5 m buffer. Each experiment was conducted as a randomized complete block and treatments replicated four times. In each field plots were managed in the same manner as the rest of the field. RWW adult populations were assessed using feeding scars; RWW immatures (larvae and pupae) were assessed using a core sampler.

Based on the number of RWW immatures and adult feeding scars at different distances from the field's edge, RWW infestations appear to be more severe near field borders and levees, especially under low to intermediate population densities. In only one location was the RWW infestation widespread throughout the field. RWW density at this location was higher than in all other locations, averaging more than two RWW larvae per core. All other locations had an average RWW population of less than one larva per core. However, near the field's edge, number of RWW larvae per core was usually higher than one, a density commonly considered as threshold in California. These results confirm that border and levee treatments in California rice are adequate to manage RWW populations.

83P
GROUND BEETLE ASSEMBLAGES FROM CONSERVATION RESERVE PROGRAM LAND IN DELTA JUNCTION, ALASKA

Alberto Pantoja[1], Aaron M. Hagerty[1], Susan Y. Emmert[1], Derek Sikes[2], and Silvia I. Rondon[3]

[1] United States Department of Agriculture, Agricultural Research Service, Subarctic Agricultural Research Unit, P.O. Box 757200, Fairbanks, AK 99775 USA
[2] Curator of Insects, University of Alaska Museum, 907 Yukon Drive, Fairbanks, AK 99775
[3] Extension Entomologist Specialist, Oregon State University, Hermiston Agricultural Research and Extension Center, 2121 South First Street, Hermiston, OR 97838

Little is known about the beneficial insect fauna associated to Alaska agricultural systems. Carabidae (ground beetles) are considered indicators of habitat disturbances and are also known to consume agricultural pests, weeds seeds, and provide a source of food to other members of the ecosystem. This work report on the abundance and species richness of Carabids from plots enrolled in Conservation Reserve Program (CRP) in Alaska. A large portion of Alaskan cropland is enrolled in the CRP and may harbor considerable populations of ground beetles. Land registered under the CRP near Delta Junction Alaska (64ºN, 145º W) was surveyed for ground beetles. Insects were collected using pitfall traps. Sampling dates were 6 June to 20 October 2006 and 18 May to 28 September 2007. A total of 6,121 specimens representing fifteen species from twelve genera were collected. Ninety-six percent of the specimens belong to five species, *Agonum cupreum* Dejean, *Amara obesa* Say, *Calathus ingratus* Dejean, *Dicheirotrichus cognatus* (Gyllenhal), and *Pterostichus adstrictus* Eschscholtz. One species collected in low densities, *Cymindis cribricollis* Dejean represents a new record for Alaska. In a similar study conducted in Oregon we found a similar species composition, but lower insect densities in potato fields as compared to the Alaska trials. To our knowledge this represents the first long term survey of Carabids associated to CRP land in Alaska.

84P
THE AFFECT OF BIODIVERSITY OF NEMATODES AND FUNGUS ON THE COLORADO POTATO BEETLE

Elizabeth Aultman, Randa Jabbour, David Crowder, William Snyder

Entomology Department, Washington State University Pullman, WA

In this paper we study the impact of biodiversity of nematodes and fungi on the control of an agricultural pest. We investigated how the relative proportions of three different species of nematodes, *Steinernema carpocapsae*, *Heterorhabditis megidis*, *Steinernema feltiae*, and a species of fungi, *Beauveria bassiana*, affect the mortality of wax worms, *Galleria mellonella*, and the Colorado Potato Beetle (CPB). In eastern Washington agriculture the Colorado Potato Beetle, *Leptinotarsa decemlineata* (Say), is a prevalent pest. We test the hypothesis that a more diverse group of parasites would result in a higher level of mortality. Evenness of species and varying soil types were also studied. We found that when a greater number of species was used, higher mortality was recorded in both the wax worms and in CPB.

85P
VOLATILE PROFILE OF FOUR POTATO VARIETIES AND THE RESPONSE OF GREEN PEACH APHID

Hongjian Ding and Sanford D. Eigenbrode

Department of Plant, Soil and Entomological Sciences, P.O. Box 442339, University of Idaho, Moscow, ID 83844-2339

Volatile organic compounds (VOC) emitted by plants can influence host finding and selection by phytophagous insects, including aphids. Here we compare the headspace VOC profile of four widely-grown varieties of potato (*Solanum tuberosum* L.) and the responses to these profiles by the green peach aphid, *Myzus persicae* (Sulzer). The tested varieties (Russet Burbank, Desiree, IdaRose and Chipeta) represent distinct pedigrees within cultivated potato. Headspace VOC of 4-week-old plants of each variety were analyzed using gas chromatography/mass spectrometry. Total VOC ranged from 3910 to 1455 ng/g (DW)/hour as follows: Russet Burbank > Desiree > Chepata > IdaRose. Thirty-six individual VOCindentified included green leaf volatiles, monoterpenes and sesquiterpenes. Principal Components Analysis readily distinguished the four varieties, whether performed using total ng/g DW/h or relative composition of their VOC blends. Movement of apterous *M. persicae* from same-aged leaflets of the four varieties was also. For this bioassay, groups of aphids were placed on fine-mesh screening directly above a single test leaflet and the number moving away from the leaflet was recorded every 10 min for 1 hour. The screening prevented direct contact with the plant surface, and the bioassay was conducted in darkness to eliminate visual cues. Data were used to calculate emigration rate parameters. Aphid emigration differed significantly among the four varieties, but was unrelated to total VOC headspace concentration. Thus, the specific composition of the VOC blend evidently influences the aphid behavior. The implications for host selection by the aphids and varietal differences in vulnerability to attack are discussed.

86P
WHITE GRUBS MANAGEMENT IN CALIFORNIA BLUEBERRIES

Natalie Hernandez and David Haviland

University of California County Extension Kern Co., 1031 S. Mount Vernon Ave. Bakersfield, CA, 93307

The larvae of scarab beetles identified as *Cyclocephala longula* feed on the roots of blueberries and cause losses in fields. During 2009 the seasonal biology of the beetle was observed to better understand the pest. The flight of the adults was monitored with light traps to begin establishing control practices. It was found that adults emerge in large numbers to mate during the month of June. Larvae were also collected to monitor the growth pattern and times at which certain instars are present in the field. Trials involving entomopathogenic nematodes *Heterorhabditis bacteriophora* were initiated. Assays were conducted using the larvae of *Gallaria spp*. along with the beetle larvae to evaluate the release of nematodes on April first of 2009. It was found that nematode releases are a viable option for managing the pest and additional studies have been initiated.

87P
CHUMMING FOR PREDATORS: HIPV LURES AS MONITORING TOOLS FOR NATURAL ENEMIES

Shawn A. Steffan, Vincent P. Jones, Callie C. Baker, and Tawnee D. Melton

Washington State University, Department of Entomology, Tree Fruit Research and Extension Center, 1100 N. Western Ave., Wenatchee, WA

When deployed as baits within standard delta traps, herbivore-induced plant volatiles (HIPVs) facilitate efficient monitoring of adult parasitic Hymenoptera, green lacewings, predaceous Hemiptera, and hover flies in orchard systems. Numerically, trap-catch was dominated by lacewings and parasitic Hymenoptera, though thousands of predatory Hemiptera and hover flies were also caught. The most attractive lure was found to be a blend of geraniol (GER), 2-phenylethanol (PE), and methyl salicylate (MS). To discern whether the attractiveness of this blend derived from sensitivity to all three components or a subset thereof, we assayed the independent and interactive effects of GER, PE, and MS on trap-catch. We found that sensitivity to these compounds was specific to each taxon—lacewings and parasitic Hymenoptera were primarily attracted to the blend of PE and MS; most predatory Hemiptera were attracted to the blend of all three compounds; hover flies favored the blend of GER and PE (unfortunately, honey bees were also highly attracted to the GER+PE blend). Our results suggest that HIPV-based trapping may be a promising new method for measuring natural enemy diversity, abundance, and phenology in the agroecosystem. Further, trapping strategies can be tailored to particular taxa.

88P
IMPROVING A CULTURAL TACTIC UTILIZED FOR MANAGEMENT OF NAVEL ORANGEWORM IN ALMONDS

Elizabeth A. Boyd[1], Justin E. Nay[2], and Kent M. Daane[3]

[1]California State University – Chico, College of Agriculture, 400 W. 1st St., Chico, CA; [2]Integral Ag. Inc., 1635 Almendia Dr., Chico, CA; [3]UC – Berkeley, ESPM, Berkeley, CA

Almond mummy sanitation in orchards during winter is essential to management of navel orangeworm (NOW), *Amyelois transitella* (Walker) (Lepidoptera: Pyralidae), a devastating insect pest of almonds. By eliminating mummies (i.e. almonds remaining in the tree after harvest), NOW are stripped of their overwintering "hotel", thus disrupting their life cycle. Trials were conducted in 'Nonpareil' almonds to determine if dormant applications of variable rates of water prior to shaking would increase the efficacy of the mechanical tree-shaker portion of a mummy sanitation program and hence reduce the per acre costs of the manual poling portion. Trials were conducted in one "wet" winter (2008) and one "dry" winter (2009). In a wet winter, there was no difference between treatments, as was expected. In a dry winter, differences were detected between the control and water treatments at 50 and 400 gallons per acre. Future research is needed to control for time-of-day interactions.

89P
MATING DISRUPTION FOR CONTROL OF NAVEL ORANGEWORM IN ALMONDS IN CENTRAL CALIFORNIA

Charles S. Burks[1], Bradley S. Higbee[2], Kent M. Daane[3], Joel P. Siegel[1], and David G. Brandl[1]

[1]USDA-ARS, San Joaquin Valley Ag Sciences Center, 9611 S. Riverbend Ave., Parlier, CA
[2]Paramount Farming Company, 33141 E Lerdo Hwy, Bakersfield, CA
[3]University of California, Dept. of Environmental Science, Policy and Mgmt.; Berkeley, CA

Previous research showed that mating disruption can significantly reduce damage by the navel orangeworm, *Amyelois transitella* (Walker), to almonds at harvest. However, that research was conducted in Kern County and primarily in the variety Nonpareil and a few varieties, such as Monterey and Carmel, commonly used as pollenizers for Nonpareil. Here we present data examining the impact of mating disruption as a part of integrated management of navel orangeworm in a different geographical location and under different conditions of production, including substantial representation of the varieties Butte and Padre. Mating disruption completely eliminated capture of males in sticky traps baited with unmated females as a pheromone source. Males captured in traps in adjacent untreated comparison plots were also greatly reduced. An extensive grid of egg traps showed less oviposition in mating disruption treatment plots than control plots. There was significantly less navel orangeworm damage in treated compared to comparison plots after mating disruption was applied, but not in pre-treatment baseline comparison plots. These data demonstrate that mating disruption had a significant impact on navel orangeworm behavior, fertility, and damage under these conditions.

90P
TREE CAGES, PLUMES AND VERTICAL DISTRIBUTION OF NAVEL ORANGEWORM: CAN WE OPTIMIZE MATING DISRUPTION?

Bradley S. Higbee[1] and Ring T. Cardé [2]

[1]Paramount Farming Company, 33141 E. Lerdo Hwy., Bakersfield, CA., 93308
[2]Department of Entomology, University of California, Riverside, CA 92521

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. With the relatively recent discovery of several minor sex pheromone components, enhancing the impact of MD on navel orangeworm control by using a more complete blend is a possibility. The field cage assay developed by Eric Doye and Uwe Koch for comparing MD treatments may provide an efficient and definitive approach to the question of relative levels of disruption attained by the major component vs. a complete blend. Our efforts to adapt this assay to NOW in almonds resulted in unexpected outcomes that led us to investigate the behavior of the moths and plume dynamics in an almond orchard. Our findings and proposed experimental approaches will be discussed.

91P
INFLUENCE OF FRAGMENTING ENVIRONMENT ON LYGUS MANAGEMENT IN COTTON

P.B. Goodell, D.A. Cary, N.C. Cannell

University of California, Cooperative Extension, Statewide IPM Program
Kearney Agricultural Center, 9240 So. Riverbend Ave, Parlier, CA

Western tarnished plant bug (*Lygus hesperus* Knight) or Lygus bug is a key pest in the cotton cropping system of the San Joaquin Valley. As the acres of cotton decreases, management of this pest becomes more challenging as cotton fields become separated and the cropping landscape more fragmented with potential Lygus host crops. As part of a large multi-state USDA-NIFA-RAMP project, we have been sampling cotton fields weekly as well as the surrounding crops. In 2008, in western Fresno County, approximately 11,000 acres of safflower were interspersed with cotton and other row crops. Cotton growers suffered substantial losses in spite of multiple insecticide applications in this environment due to a lack of area-wide management of Lygus in safflower. Safflower provided an essential biological bridge into which overwintering populations could establish, reproduce and be released into neighboring crops. In 2009, an equivalent acreage of safflower was planted, but into a "planned landscape". This situation can be contrasted to 2008 in the level of management, the concentration of fields, the reduction in border interface and the success in mitigating the movement into surrounding cotton. These data demonstrated that landscapes can be managed to minimize pest infestation on a large area.

92P
SKY ISLAND BEES OF THE MOJAVE DESERT

Terry Griswold[1]

[1]USDA-ARS Bee Biology & Systematics Laboratory, Utah State University, Logan UT 84322-5310

The higher mountain ranges of the eastern Mojave Desert, rising as much as 3450 meters above the adjacent valley floors, constitute isolated islands of temperate climate in a sea of desert. The bees that inhabit these sky islands are little known. Studies conducted in Inyo County and eastern San Bernardino County, California and Clark County, Nevada that included sampling in montane areas suggest a rich and distinctive bee fauna whose primary affinity is with cismontane California. Disjunct populations of seven species of bumble bees (*Bombus*) occur on one or more mountain ranges compared to the single species found in the surrounding desert. Most diverse is the previously undocumented *Bombus* community of the Spring Mountains. The majority of sky island restricted bees appear to belong to the family Megachilidae including disjunct populations of species of *Anthidium, Dianthidium, Stelis, Megachile, Ashmeadiella, Atoposmia, Hoplitis, Osmia,* and *Protosmia.* The megachilid genus *Xeroheriades* is endemic to a few mountain ranges of the eastern Mojave.

93P
CITIZEN SCIENTISTS WITHOUT VOTING RIGHTS: BEEKEEPING PRACTICE AND RESEARCH IN WASHINGTON STATE PRISONS

Samuel D. Hapke[1], Daniel Travatte[2], and Nalini M. Nadkarni[3]

[1]SpringStar Inc., P.O. Box 2622, Woodinville, WA, 98072, U.S.A.
[2]Cedar Creek Corrections Center, Littlerock, WA, 98556, U.S.A.
[3]The Evergreen State College, Olympia, WA, 98505, U.S.A.

Despite annual increases in demands for pollination services, the number of professional beekeepers in the United States continues to shrink. Human housing expansion may be contributing to this decline by rendering landscapes incapable of supporting large numbers of managed colonies and increasing the number and frequency of adverse interactions between beekeepers and the general public. Less densely populated areas and interested newcomers are thus at a premium for the beekeeping industry. Often located in rural areas away from dense human populations, prisons offer a unique, untapped geographical resource to support wild and commercial plant pollination. Additionally, they hold large numbers of individuals who have rigidly structured work schedules and are eager to learn new skills. Here we report on beekeeping training programs and a scientific experiment conducted in Washington State prison facilities. Offenders were trained in honey bee biology, basic entomology, beekeeping, and native pollinator diversity in classroom lectures and hands-on field exercises. Hive equipment was built and repaired in the prison wood shop and colonies were imported from a local beekeeper. Inmates were then entrusted to tend the colonies and hive equipment on the prison grounds. The prison environment engendered a mutually-beneficial exchange of ideas and respect between offenders and visiting scientists. Prisoners gained scientific and vocational training while scientists discovered a new alternative audience to aid in data collection. Information gathered during this pilot program lays the groundwork for future collaborations between local correctional departments and both the academic and commercial beekeeping communities.

94P
PREDICTING POLLEN BALLS IN ALFALFA LEAFCUTTING BEES

Theresa L. Pitts-Singer

USDA ARS Bee Biology & Systematic Laboratory, Utah State University, Logan, UT 84326

Commercial populations of the alfalfa leafcutting bee, *Megachile rotundata* F. (Hymenoptera: Megachilidae), are difficult to sustain in the United States for annual pollination of alfalfa for seed production. Most alfalfa seed growers must purchase bees from Canada, where populations thrive and can increase. An intense observational and monitoring study was performed in summer 2008 to determine the cause of reproductive loss in alfalfa leafcutting bees due to the lack of larval development, known as pollen ball. Frequent assessment of nest progression of individually-marked female bees revealed when cells were created that became pollen balls, when cells were created that contained immatures that succumbed to a disease or parasites, and when cells were created that produced a summer-emerging or diapausing bee. Cell destinies

could be correlated with variables such as temperature, the age of the nesting bee, the sequence of the cell in relation to other cells or nests belonging to the same bee, the size of the nest provision, and the availability of floral resources. Results showed that pollen balls occurred most often at higher temperatures, when cells were in the third to sixth position in the nest, and when provisions were relatively small.

95P
YEAR-ROUND IPM PROGRAMS CONNECT UC IPM ENVIRONMENTAL QUALITY RESOURCES

Tunyalee Martin, Barbara Ohlendorf, Jodi Azulai, Carolyn Pickel, Pete Goodell, Joyce Strand

UC Statewide IPM Program, One Shields Avenue, University of California, Davis, CA

UC Agriculture and Natural Resources (ANR) authors and the UC Statewide Integrated Pest Management Program (UC IPM) work together to produce the Year-Round IPM Programs (YRPs). Composed of ANR scientists, Crop Teams gather the most current research-based information for inclusion in the YRPs. The YRPs guide users through a year of monitoring, prevention, and management practices required to carry out a comprehensive IPM program. Unlike the Pest Management Guidelines, which organizes information by pest, the YRPs present the major activities by growing season and more closely aligned to grower practices. Environmental quality is a focus of the YRPs, connecting to tools such as monitoring forms and the Degree-Day Calculator, a statement listing the crop's special issues related to environmental quality for each growing season, and the Pesticide Application Checklist linking to the WaterTox database, information on pesticide impacts on natural enemies, and references to relevant ANR 8000 series publications. Recently new YRPs were developed for dry beans, lettuce and, cherry.

96P
INTEGRATED PEST MANAGEMENT VS GROWER'S STANDARD PEST CONTROL PRACTICE FOR MANAGING THE INSECT PESTS ON CABBAGE IN GUAM

Gadi V.P. Reddy

Western Pacific Tropical Research Center, College of Natural and Applied Sciences, University of Guam, Mangilao, Guam 96923

The effect of biorational and synthetic organic insecticide application regimes were evaluated for the management of key pests of cabbage in Guam in 2008 and 2009. Cabbage plants were grown in small replicated plots and pests were managed either under a regime of synthetic organic insecticides popularly used by growers (malathion or carbaryl) or biorational techniques, dipel *Bacillus thuringiensis* and neem (Aza-Direct). Effectiveness of the treatments was evaluated by estimating the population density and marketable- yield levels. Incidence of attack by different insect pests was assessed by counting the number of insect stages and damage ratings in eight randomly selected plants in each treatment plot. The biorational treatments were significantly more effective than the synthetic organic insecticides in controlling lepidopterous pests and serpentine leaf miner. Biorational methods (three sprays of neem + three sprays of dipel, on

rotation basis) at 15, 30, 45, 60, 75 and 90 days of transplanting resulted in greater marketable yield than the synthetic organic insecticides. The best treatment found from the previous experiments was selected for the demonstration trial. Similarly, five fields were selected where regular spray schedule are being done at various locations in Guam. Results indicated that low pest incidence and higher yield was recorded in the IPM demonstration plots while higher pest incidence and low yield levels were obtained in the regular spray schedule fields.

97P

CUTTING FAILURE AND DAMAGE CHARACTERIZATION IN PACIFIC NORTHWEST HYBRID POPLARS

R. Andrew Rodstrom, John J. Brown, John R. Rodstrom and Martin E. Fortney

Washington State University, Department of Entomology, Pullman, WA

Hybrid poplars grown in the inland Pacific Northwest are an irrigated woody crop grown to meet today's fiber demands. Harvest generally occurs during winter when most pests are dormant. In spring, growers replant the recently harvested areas with cuttings. Due to the small leaf area, fragile roots and limited reserves, cuttings are vulnerable to several common above and below ground pests during this first growing season. These cuttings represent a long-term investment and it is imperative for the grower to know which pests are causing economic injury and where it is occurring. Cutting mortality within planting blocks was recorded, characterized and then visualized using Spatial Analysis and Decision Assistance (SADA). This technique allowed for the recognition of species-specific mortality patterns within a planting block. Our findings indicate that even though the location of cutting mortality occurs haphazardly within a block, species-specific mortality patterns are discernable across multiple blocks. It is our understanding that these patterns are linked to a pest's mobility, with highly mobile pest showing a broad distribution and sessile pests causing localized pockets of mortality. Even though our project has brought new light to this system through the identification of the major cutting pests and characterized their damage and mortality patterns, we are unable to predict where these insect-caused mortalities will occur within a newly planted block. During this project we developed novel control techniques, such as a prophylactic dip to protect cuttings from subterranean pests and propagation techniques. These techniques include the planting of poles in place of sticks, which dramatically reduces mortality in the first year of planting.

MINI-SYMPOSIUM: MEALYBUG MANAGEMENT UPDATE

98P

MEALYBUG PHEROMONES: MOVING FROM DISCOVERY TO APPLICATIONS

Jocelyn Millar[1], Steve McElfresh[1], Yunfan Zou[1], Rebeccah Waterworth[1], Kent Daane[2], Walt Bentley[3]

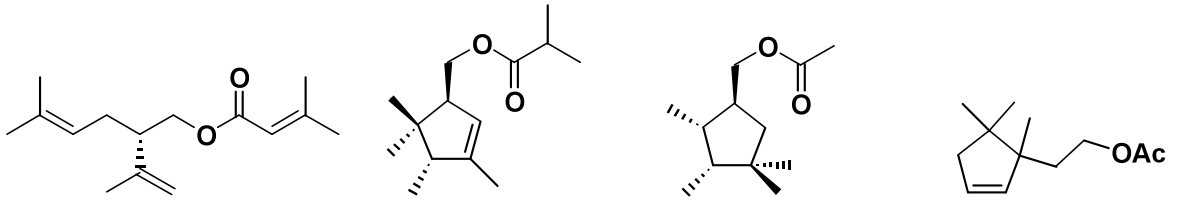
[1] Department of Entomology, University of California, Riverside CA 92521
[2] Environmental Science, Policy, & Management, University of California, Berkeley CA 94720
[3] Kearney Agricultural Center, 9240 South Riverbend Ave., Parlier CA 93648

Mealybugs can cause significant problems in vineyards due to feeding damage and buildup of detritus from insects, and the growth of molds and fungi on honeydew produced by the mealybugs. The importance of mealybugs as pests has increased dramatically over the past few years due to their role in vectoring leafroll viruses and other major diseases affecting grape production. Over the past ten years, we have identified and synthesized the female-produced sex pheromones of the four most important mealybug species in vineyards in the western United States, including the invasive vine mealybug, and the endemic longtailed, obscure, and grape mealybugs. All of the pheromones consist of a single, unique component, with vine mealybug producing the largest amounts of pheromone, and grape mealybug producing the least. Vine mealybug pheromone also has the simplest structure, and it is easy to make in any desired quantities. The structures of the pheromones of the other species are a lot more complex, but we have now developed syntheses for all of these pheromones on gram scale.

The pheromones have a number of desireable attributes. First, the pheromones of all species are extraordinarily active, with lures loaded with 25 micrograms of pheromone having effective field lifetimes of at least several months. Second, the pheromones appear to be species specific, so that no sorting of trapped insects for full identification is necessary. Third, the pheromones do not interfere with each other, so that the pheromones of different species can be combined to make "generic" lures that will attract several species simultaneously, if a grower is only interested in whether or not mealybugs are present.

The pheromones of the different species are in various stages of development and commercialization. Vine mealybug pheromone has been commercially available for almost ten years, and it has been extensively used to detect and monitor the spread of this insect throughout California. Pheromone lures for longtailed mealybug should become commercially available this year, whereas the pheromones of grape and obscure mealybugs are currently being used for field research in vineyards in the western US, and are in the development pipeline. Some of the considerations involved in getting these pheromones from the lab bench to growers and other end users will be discussed.

MEALYBUG PHEROMONE STRUCTURES



Vine mealybug **Grape mealybug** **Obscure mealybug** **Longtailed mealybug**

99P

2009 GRAPE MEALYBUG (GMB) (*Pseudococcus maritimus*) AND VINE MEALYBUG (VMB) *(Planococcus ficus*) (PSEUDOCCOCIDAE) SURVEY IN IDAHO VINEYARDS

Ben Simko, Darcy Heckathorne, and Martin Fujushin

Idaho State Department of Agriculture, Boise, Idaho

GMB is reported in literature as a native North American species. A description of the GMB (Bakers mealybug) is included in *The Insects of Western North America*, E.O. Essig, 1946 edition. The 2009 edition of the PNW Insect Management Handbook includes management guidelines for this insect in the Grape Pest Section. VMB is an invasive species recently established in several California grape producing areas and is established as far north as Napa and Sonoma Counties

Both wine and table grape plantings were surveyed in Idaho for two species of grape infesting mealybugs; the GMB, *Pseudococcus maritimus* and the VMB, *Planoccoccus ficus*. A total of 91 vineyards were selected in 10 Idaho counties. The survey utilized green delta traps baited with synthetic female pheromone for the two species. Pheromone lures were provided by Dr. Jocelyn Millar, Entomology Department, University of California, Riverside. Additional plant surveys looking for mealybug colonies were done as part of the regular servicing of the male mealybug traps. The trapping duration for the VMB males averaged 100 days.

Species determinations on male mealybug specimens captured in the traps as well as females collected on vines were made at ISDA with technical and diagnostic assistance from Dr. Gillian Watson, California Department of Food and Agriculture, Plant Pest Diagnostic Center, Sacramento, CA and Dr. Penny Gullan, University of California, Davis, Entomology Department, Davis, CA. GMB traps at all survey sites were positive for *Pseudococcus maritimus* males. Infestations of immature and adult female GMB were found at 13 vineyards surveyed with 11 records in Canyon County, one record in Owyhee County, and one record in Twin Falls County. Slide mounts of females were prepared at ISDA with final determinations made by Dr. P. Gullan, University of California, Davis. No active infestations of GMB were observed in the seven vineyard sites in the Lewiston, Idaho area although all traps captured GMB males. **No VMB males were captured at any of the vineyard sites, nor were any infestations of VMB found in the grape plantings.** Previous to this survey, University of Idaho W.F.Barr Entomological Museum did not have an official state record or specimens of *Pseudococcus maritimus* in its collection. Anecdotal reports from vineyard managers indicate first GMB infestations were observed in Canyon County, ID in 2004. The Idaho wine and table grape industries are developing IPM systems to deal with the emerging GMB pest status and the increasing incidence of grape leafroll virus which is vectored by this insect.

100P
PHEROMONE MONITORING OF FOUR MEALYBUG SPECIES IN OREGON VINEYARDS

Richard Hilton[1], Vaughn Walton[2], Marcus Buchanan[1], Amy Dreves[2], Steve Castagnoli[3], Clive Kaiser[4], Jocelyn Millar[5], Steve Renquist[6], Philip VanBuskirk[1]

[1]OSU Southern Oregon Research & Extension Center, 569 Hanley Rd., Central Point, OR
[2]Oregon State University, Department of Horticulture, Corvallis, OR
[3]OSU Mid-Columbia Agricultural Research & Extension Center, 2990 Experiment Station Dr., Hood River, OR
[4]OSU Umatilla County Extension, 418 N. Main St., Milton-Freewater, OR
[5]University of California Riverside, Department of Entomology, Riverside, CA
[6]OSU Douglas County Extension, P.O. Box 1165, Roseburg, OR

Mealybugs can serve as vectors of the grapevine leafroll virus. Mealybugs can spread leafroll virus within a vineyard and movement of mealybug-infested fruit or equipment can potentially spread the leafroll virus between vineyards. In 2009, a survey of grape-infesting mealybugs was conducted using pheromone baited traps in over 40 vineyards encompassing all major Oregon grape growing areas in order to get baseline data of current infestation levels. Traps for four mealybug species were compared: vine mealybug, *Planococcus ficus* (Signoret); obscure mealybug, *Pseudococcus viburni* (Signoret); longtailed mealybug, *Pseudococcus longispinus* (Targioni Tozzetti); and grape mealybug, *Pseudococcus maritmus* (Ehrhorn); along with a mixture of all four mealybug pheromones. Over 200 traps were placed as part of the comparison and over 50,000 mealybugs were caught. Most of the mealybugs (99.97%) were trapped with either the grape mealybug or mixed pheromone lures and the numbers of mealybugs caught with those two lures was highly correlated. The trap capture was unevenly distributed. Approximately 63% of the total mealybugs trapped were from a single vineyard in southern Oregon and the four vineyards with the highest capture, three in southern Oregon and one in the mid-Columbia area, accounted for almost 93% of the total. Six mealybugs were caught in vine mealybug traps and these captures were almost certainly stray grape mealybugs since the catch usually occurred in locations where grape mealybug catch was very high and in follow-up examinations only grape mealybugs were found on the plants, in no instance were vine mealybugs observed on grapevines.

101P
MONITORING AND MANAGEMENT OF GRAPE MEALYBUGS IN WASHINGTON STATE

Brian Bahder, Dan Groenendale, Deborah Brooks, Naidu Rayapati and Doug Walsh
WSU Irrigated Agriculture Research and Extension Center, Prosser, WA

Mealybugs have been identified as a primary vector of grapevine leafroll disease (GLD) in Washington vineyards. Successful management of this devastating disease in Washington State vineyards will depend upon accurate diagnosis and appropriate management of mealybug infestations. While GLD has primarily been an economic pest in wine grapes only (studies are

underway to determine its impact on juice grapes), monitoring juice grape vineyards for mealybug infestations is enabling us to conduct studies on the epidemiology of GLD potentially reducing the disease spread to uninfected vineyards of both types. Dr. Jocelyn Millar, our own renowned PBESA pheromone chemist has supplied us with the sex pheromones for grape mealybug, obscure mealybug, long-tailed mealybug, and vine mealybug and we field deployed them in preliminary tests for their use as tools for monitoring mealybug populations in a series of grower-collaborator vineyards. Fortunately no mealybug males except grape mealybug were captured in any of the traps we placed in over 1,200 acres of Washington vineyards in 2009. We have also conducted insecticide efficacy trials against mealybugs for the past 11 years. We will cohesively summarize these results.

102P
MATING DISRUPTION FOR THE VINE MEALYBUG: CAN SEX PHEROMONES CONTROL RELATIVELY SESSILE HEMIPTERAN PESTS?

K. M. Daane[1], M. L. Cooper[2], J. G. Millar[3], G. Y. Yokota[1], V. M. Walton[4], W. J. Bentley[5], E. A. Boyd[6]

[1] University of California, Dept. Environmental Science, Policy & Management, Berkeley, CA
[2] University of California, Cooperative Extension, Napa County, Napa, CA
[3] Department of Entomology, University of California, Riverside, CA
[3] Department of Horticulture, Oregon State University, Corvallis, OR
[3] University of California, Statewide IPM Program, Kearney Agricul. Center, Parlier, CA
[6] California State University, Department of Plant Science, Chico, CA

Vine mealybug, *Planococcus ficus* (Signoret) invaded California vineyards around 1990. It has since spread to most California vineyard regions and has the potential to spread throughout the western USA, causing damage by contaminating fruit and vectoring pathogenic viruses. We tested combinations of biological controls, ant controls, and mating disruption to develop an effective IPM program. Here, we describe the development of a mating disruption, from initial trials through procurement of an EPA Section 18 and final commercialization. Mating disruption using the sex pheromone dispersed in plastic dispensers was tested in combination with insecticides in Fresno, Kern, Napa, San Joaquin, San Luis Obispo, and Sonoma counties. Trials showed significantly lower season-long trap catches of adult males, lower season-long mealybug densities, and less crop damage in mating disruption blocks. In most successful trials, mating disruption was combined with insecticide applications. Factors that impact the effectiveness of mating disruption were (1) the initial mealybug density as the program was ineffective in vineyards with moderate to high pest pressure, (2) interaction between the synthetic sex pheromone and *Anagyrus pseudococci*, a key natural enemy of the mealybug, (3) and repeated annual application. We discuss the potential and problems of integrating a mating disruption program into grower operations for wine and table grapes.

103P
REFINEMENT OF IPM PROGRAMS FOR VINE MEALYBUG IN SAN JOAQUIN VALLEY TABLE GRAPES

David R. Haviland, Stephanie M. Rill, and Jennifer Hashim-Buckey

University of California Cooperative Extension, Kern Co.
1031 S. Mount Vernon, Bakersfield, CA 93307

Vine mealybug is one of the most prolific pests of table grapes in the San Joaquin Valley of California. Its exponential growth rate and affinity for feeding within clusters close to harvest make its management of highest priority for grape growers dealing with infested vineyards. For the last two years we have conducted several in-season trials to evaluate different insecticides and application timings for vine mealybug management. Movento was effective when used in April, May or June regardless of table grape variety. Lorsban, when applied in late February prior to budbreak, consistently provided 50% reductions in vine mealybug damage at harvest. The effectiveness of neonicotinoids in these trials, which were all done on sandy loam soils, followed a trend of water solubility of the active ingredients. Soil applications of Clutch and Admire resulted in mealybug densities that were lower than those in plots treated with Platinum, which were lower than in those treated with Venom. This presentation will discuss these results in more detail and provide implications on how these results can be used to develop season-long approaches to vine mealybug management.

104P
CHALLENGES ASSOCIATED WITH DEVELOPMENT AND COMMERCIALIZATION OF A NON-LEPIDOPTERAN PHEROMONE FOR MATING DISRUPTION USE IN WESTERN VINEYARDS

Carlos C. Reyes, Ph.D.
Suterra LLC, Bend, OR

The geographic distribution and market segments (wine, table, and raisin) of grape production in the western United States create a vast and multifaceted range of needs to consider when developing pest management solutions. As a class of compounds for pest management, generally pheromone proof of concept in field research is burdened by demonstrating “biological activity” in the form of trap shut down, and/or reduced egg lay translates into “efficacy” in the form of reduced crop damage, and/or reduction in other pest management inputs. In the case of lavandulyl senecioate, the pheromone for attracting/disrupting male vine mealybug (*Planococcus ficus*), commercialization is further complicated by a regulatory process that is not optimized to review non-lepidopteran pheromones.

STUDENT-SPONSORED SYMPOSIUM: SUSTAINABILITY IN THE EVOLVING WORLD: INSECTS, ECOSYSTEM, AND ECONOMICS

105
LINKING SUSTAINABLE PRODUCTION AND BIODIVERSITY CONSERVATION: A TEAM-BASED INTERDISCIPLINARY GRADUATE STUDENT PROGRAM EXPERIENCE

Nilsa A. Bosque-Pérez
Department of Plant, Soil and Entomological Sciences, P.O. Box 442339,
University of Idaho, Moscow, ID 83844-2339

Achieving sustainable production and biodiversity conservation in anthropogenically-fragmented landscapes requires scientists educated in a holistic fashion and an emphasis on interdisciplinary collaboration and teamwork. Traditional graduate programs in agriculture, forestry and conservation biology fall short of this goal as they educate scientists with research skills in narrowly defined disciplines and rarely facilitate integration across disciplines. We discuss some of the lessons learned from a graduate education and research project funded by the National Science Foundation Integrative Graduate Education and Research Traineeship (NSF-IGERT) program that developed and evaluated an integrative educational model with an emphasis on developing interdisciplinary team research skills and knowledge in the biological, physical, and social sciences. Entomological research conducted in Costa Rica on coffee, cacao and banana agroforestry systems will be highlighted. Examples of team research will be presented to illustrate the nature, challenges, and successes of this graduate program.

106
AN INTERNATIONAL PERSPECTIVE ON FACTORS AFFECTING THE EXPANSION OF AUGMENTATIVE BIOLOGICAL CONTROL IN THE GREENHOUSE ECOSYSTEM

Michael P. Parrella
Department of Entomology, University of California, Davis

The production of primary agricultural products in the protected environment offered by greenhouses continues to expand on a global basis. Production in all forms of greenhouses is estimated to be as much as 2,400,000 hectares worldwide with approximately 45,000 hectares under glass. With the inclusion of recent estimates from southern Spain and China, augmentative biological control (ABC) is practiced on approximately 40,000 hectares or less than 2% of this total area. Much of this ABC is concentrated in Northern and Southern Europe, followed by (in decreasing order) North America, Asia, Africa and South America. Biological control of arthropod pests is a key component of the development and implementation of sustainable production systems in protected culture AND will continue to expand in the future. In this presentation I will discuss the factors both favoring and limiting the expansion of ABC in the greenhouse ecosystem using *Liriomyza* leafminers as a model system.

107

SUSTAINABLE INTEGRATED PEST MANAGEMENT PROGRAMS THAT ADDRESS NEEDS OF FARMERS, CONSUMERS AND THE ENVIRONMENT: A PERSPECTIVE

Walter Bentley
University of California Statewide Integrated Pest Management Program,
Kearney Agriculture and Research Center, 9240 South Riverbend Avenue, Parlier, CA 93277

The tools available to farmers and pest control advisers for developing integrated pest management programs (IPM programs) have greatly improved during the last decade. Most often we think of the use of selective pesticides and, in particular, insecticides and miticides that are selective to target pests, benign to the environment and safe to farm workers and consumers. Products such as spinosad, methoxyfenozide, and rynaxypyr are but three such examples. However, there are other advances that we, as entomologists have come to take for granted. More impressive than the development of selective insecticides has been the advances in pheromone technology. The development of pheromone monitoring techniques has allowed us to detect pests, easily, and to tract their development in the ecosystem. In essence, the pests in question will come to us instead of us going to them.

In some cases these monitoring devices have been used to establish action thresholds. One of the earliest such uses involves spray thresholds for potato tubermoth (*Phthorimaea operculella*) in California. More recently pheromones have been used to impact mating and population development. Pests such as codling moth (*Cydia pomonella*), Oriental fruit moth (*Grapholita molesta*), European grapevine moth (*Lobesia botrana*), and tomato pinworm (*Keiferia lycopersicella*) are but a few examples of successful mating disruption programs now common in agriculture. Mating disruption continues to be developed for many pests throughout the world.

Selective pesticides and pheromone technology have now allowed for the true integration of biological control into crop production systems where, since the use of DDT, it had not been possible. Parasitoids and predators can now play a key role in the commercial management of pests.

A few crops where these advances in pest management are currently widely used include grape, peach, plum, apple, almond, walnut, and potato. In each of these crop systems selective insecticides, pheromone monitoring/mating disruption, and biological control are important components of the pest management program. I have been fortunate to take part in the implementation and, in some cases, the development of these techniques in each of these crops.

Advances in crop production techniques have positively and negatively impacted IPM. The development of rootstocks that impart disease and insect resistance are positive. The improvement tree planting and irrigation methods are positive for production and water conservation but foster the presence of ants that negatively affect biological control.

Global marketing of fresh fruits and vegetables, in the absence of fumigation, will further impact the implementation of successful IPM programs in the United States. This is particularly true when exporting commodities to countries that consider a pest or pests in the US as invasive to

their country. Pests such as Oriental fruit moth, peach twig borer (*Anarsia lineatella*) and western flower thrips (*Frankiniella occidentalis*) are consider as invasive into countries such as Australia, New Zealand and Taiwan. Non crop pests also fall into this category. Movement of black widow spider (*Latrodectus spp.*) in table grapes to Europe, Asia and Australia has greatly impacted the approach to integrated pest management in that crop.

Alternatively we must, as never before, become aware of pests that are present in countries from which we import. These countries can harbor pests such as Asian citrus psyllid (*Diaphorina citri*), Pink hibiscus mealybug (*Maconellicoccus hirsutus*), and Diaprepes root weevil (Diaprepes abbreviatus), to name just a few. Foreign markets are quite lucrative and, for farm sustainability, these markets are important. Integrated pest management in the global arena is a problem that you young entomologists will need to address. You must now consider how our pests are viewed in countries where we export and know those pests in countries from which we import. This was unheard of a decade ago. But, opening markets is a key to farm sustainability and we, as agricultural entomologists, must be able to help solve such problems faced by US farmers.

108
PRACTICAL APPLICATIONS OF CHEMICAL ECOLOGY: KNOW WHEN TO HOLD 'EM, KNOW WHEN TO FOLD 'EM

Jocelyn G. Millar
Department of Entomology, University of California, Riverside CA 92521.

Today, there are several thousand insect pheromones and related types of behavior-modifying chemicals known for insects. However, only a small percentage of these compounds have found their way into mainstream use, despite the fact that these chemicals have distinct advantages as potential pest management tools (e.g., essentially no environmental pollution problems or other nontarget effects). This suggests that research and development efforts should become more focused, so that resources are devoted primarily to development of semiochemicals that have a reasonable chance of becoming profitable products with self-sustaining markets. Alternatively, there may be a short-term or one-time need for semiochemical where other concerns supercede the need for profitability, as for example, when using semiochemically baited traps for detection of an invading species. Here, I will review several case studies that illustrate a variety of economic and biological circumstances where there is a reasonable possibility of developing successful semiochemical products. Conversely, cases in which no good argument can be made for expenditures of time and resources on research and development of new semiochemical products will be presented, along with reasons why such development would be financially or biologically impractical, or both. Finally, I will touch on the growing problem of "behavioral resistance" to semiochemical products by the general public.

109
EVALUATING ESTABLISHMENT OF BIOLOGICAL CONTROL AGENT BIOTYPES USING MOLECULAR METHODS

Marianna Szűcs[1], John F. Gaskin[2], Mark Schwarzländer[1]

[1]Department of Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID 83844-2339, [2]USDA Agricultural Research Service, Northern Plains Agricultural Research Laboratory, 1500 North Central Avenue, Sidney, MT 59270, USA

Biological control of invasive plants with insect herbivores provides a sustainable alternative to herbicide use. The high cost and lengthy process to develop a new biocontrol agent or to introduce different biotypes of a successful agent often hinder biological control efforts for invasions in environments different from those, to which the released biocontrol agent is well adapted. Molecular methods can provide a cost effective tool to assess the identity of morphologically identical insect biotypes established under various environmental conditions. The ragwort flea beetle (*Longitarsus jacobaeae* Waterhouse) is largely responsible for the control of the invasive tansy ragwort (*Senecio jacobaeae* L.) in coastal western United States. However, quantifying the effects of these flea beetles on tansy ragwort distribution and density in different climates is difficult due to the introduction of two distinct biotypes, of Italian and Swiss origin. Both biotypes have been released in California at the same time upon the initial introduction of the agent in 1968, and more recently in Montana at a newly discovered high elevation infestation of tansy ragwort. Since the biotypes are morphologically indistinguishable only prolonged observations of their differing phenologies can ascert which biotype(s) established in a given environment. Moreover, the two biotypes readily hybridize in the laboratory and the hybrids exhibit phenologies different from those of either parental biotype. We are using amplified fragment length polymorphisms (AFLPs) to evaluate which biotype(s) or hybrids provide control in low and high elevation environments in California, Oregon and Montana. The relatively quick results and high resolution obtained with this method can greatly aid the biologically based management of new tansy ragwort infestations or other fast spreading invasives for that matter, as it identifies biological control agent biotypes best suited for specific environments.

110
KEEPING THE DEVIL AT BAY: USING THE IDLE HANDS OF PRISONERS IN SUSTAINABILITY PRACTICE AND RESEARCH

Samuel D. Hapke[1] and Nalini M. Nadkarni[2]

[1]SpringStar Inc., P.O. Box 2622, Woodinville, WA, 98072, U.S.A.
[2]The Evergreen State College, Olympia, Washington 98505, U.S.A.

To implement sustainable changes on a global scale, all sectors of society must be considered and become involved. Prison facilities, which house nearly 2,500,000 people in the United States, consume food, water, energy, and financial resources, and annually generate hundreds of tons of solid waste. By bringing sustainability training and scientific research into WA State prisons, the Sustainable Prisons Project (SPP) at The Evergreen State College (Olympia, WA)

strives to dampen the environmental and psychological impacts of the prison system while contributing valuable research to the scientific community. The SPP instructs and oversees offenders in sustainable initiatives, such as gardening, composting and recycling, which directly reduce the environmental footprints of prisons. Additionally, green collar and scientific training may stem costly recidivism by providing offenders with marketable skills for use upon release. At the heart of the project's successes, which include rearing endangered species, researching moss growth, and keeping honey bees, has been the unique educational interface between scientists and offenders. As inmates benefit from the respect and enthusiasm of visiting scientists, their instructors learn to guide (and never underestimate) alternative audiences and to implement research in a novel and highly visible setting. The SPP programs should serve as models for future collaborations between the scientific world and enforced residential institutions.

111
AGRO-ECOSYSTEMS, SUSTAINABILITY OF BUMBLE BEE POLLINATORS, AND ECONOMIC CROP PRODUCTION: THE WILLAMETTE VALLEY EXPERIENCE

Sujaya Rao
Oregon State University, 3017 ALS Corvallis OR 97331

There are widespread concerns about declines in the numbers and distribution of endemic bees. Concerns relate, in particular, to bumble bees, *Bombus* spp. (Hymenoptera: Apidae), which are important pollinators of native plants and crops. In Europe, *Bombus* populations have been closely monitored for decades, and loss of bumble bees and their nesting sites have been attributed largely to anthropogenic activities such as habitat fragmentation due to agricultural intensification and urbanization. To counteract the negative effects of modern agriculture on the environment, agri-environment schemes have been implemented through which financial incentives have been provided to farmers to manage their farms for the benefit of biodiversity, including that of bee pollinators. However, densities of bumble bees have been documented to be determined not by the proportion of semi-natural habitats but by the presence of rewarding mass flowering crops in agricultural landscapes. Bumble bee colonies live for several months while bloom in a crop lasts for just a few weeks. Hence, one mass flowering crop alone is usually not adequate for sustaining a bumble bee colony through the year.

We will present a contrary perspective to bumble bee declines while describing the abundant and diverse bumble bee fauna in Oregon. Based on our observations, this rich fauna has been sustained by the practice of farming of bee-pollinated crops that bloom in sequence, and in synchrony with foraging by a complex of bumble bee species. In support of our opposing perspective to the pollination crisis, we will present results of our studies in which we estimated the diversity and abundance of native bumble bees in a spring crop and a summer crop. We will also present data that suggests that the bumble bee abundance in cropping systems can lead to reduced dependence on honey bee rentals and more economic crop production. Based on our studies, we recommend integration into conservation approaches of multiple agro-ecosystems that bloom in sequence for sustaining and building bumble bee populations.

112

WHAT GOOD ARE BUGS? THE CASE FOR INVERTEBRATE CONSERVATION

Scott H. Black

The Xerces Society for Invertebrate Conservation, Portland, OR 97215

- You can thank insect pollinators for one third of every mouthful of food that you eat.
- Grizzly bears in the Rocky Mountains of Montana get over one quarter of their yearly calories from eating moths.
- Without the lowliest flies in a stream for young fish to eat – your last grilled salmon would have been impossible.
- In fact the direct benefit of insects to Americans has been calculated to be worth more than $57 Billion a year.

With well over 1 million known species, insects and other invertebrates eclipse all other forms of life on Earth. The ecological services of insects, such as pollination, are vital to life on this planet. Though they are indisputably the most important creatures on earth, invertebrates are often overlooked. Many people can identify an endangered Bengal tiger, but few can identify an endangered Salt Creek tiger *beetle*. Scott Hoffman Black will explain why we should be concerned with conserving insect habitat and highlight important ways we can better protect this valuable resource.

Scott Hoffman Black is Executive Director of the Xerces Society, the international organization dedicated to protecting biological diversity through invertebrate conservation. He is an, ecologist and entomologist. He has extensive experience in endangered species and native pollinator conservation. As a researcher, conservationist and teacher he has worked with small issues groups and large coalitions for over 25 years advocating science based conservation. Scott has authored many scientific and popular publications and his work has been featured in newspaper, magazines and books and on radio and TV.

113

REDUCED-RISK INSECTICIDES AS TOOLS FOR SUSTAINABLE MANAGEMENT OF OBLIQUEBANDED LEAFROLLER (LEPIDOPTERA: TORTRICIDAE)

Ashfaq A. Sial[1], Jay F. Brunner[1], and Stephen F. Garczynski[2]

[1]WSU, Tree Fruit Research and Extension Center, Wenatchee, WA 98801
[2]Yakima Agricultural Research Laboratory, USDA-ARS, Wapato, WA 98951

Obliquebanded leafroller (OBLR), *Choristoneura rosaceana* (Harris), is one of the major pests of tree fruits in Washington. Use of broad-spectrum insecticides against OBLR for decades has led to the development of insecticide resistance in this pest. Recently registered insecticides, chlorantraniliprole and spinetoram, show promise for controlling OBLR, but resistance evolution is a concern. Risk assessment for resistance to a particular insecticide before its occurrence in the field could be valuable in developing strategies to manage susceptibility. Studies were initiated to screen field-collected populations and select a laboratory population for resistance against chlorantraniliprole and spinetoram using a diet incorporation bioassay. After six generations of selection, 7- and 4-fold increases in LC_{50} values were observed for chlorantraniliprole and spinetoram, respectively. Realized heritability values were estimated as 0.17 for chlorantraniliprole and 0.18 for spinetoram. Based on the response quotient values, the rate of resistance development in OBLR was slower against spinetoram than that against chlorantraniliprole. In the absence of insecticide selection, the chlorantraniliprole- and spinetoram-resistant populations reverted to susceptibility in five and six generations, respectively. Furthermore, detoxification enzyme assays indicated that the activity of esterases was significantly higher in chlorantraniliprole-selected population whereas levels of oxidases were significantly increased in the spinetoram-selected population. These results indicate that the risk of resistance evolution exists in OBLR against chlorantraniliprole and spinetoram. However, instability of resistance and apparent involvement of different classes of detoxification enzymes in resistance against chlorantraniliprole and spinetoram should make this pest amenable to resistance management strategies involving rotation of these two chemicals.

SYMPOSIUM: ORGANIC TREE FRUIT PEST MANAGEMENT IN THE WEST: BRINGING NEW SCIENCE TO OLD PROBLEMS

114
ORGANIC TREE FRUITS AND NUTS: GROWING, GROWING, GONE?

David Granatstein and Elizabeth Kirby

Center for Sustaining Agriculture and Natural Resources, Washington State University
1100 N. Western Ave., Wenatchee, WA 98801

As the market demand for organic foods has grown, so has the production base in the U.S. The semi-arid regions of the western U.S. have proven to be well-suited for organic tree fruit and nut production, with relatively fewer pest and disease problems than more humid regions. California is the primary producer of conventional and organic walnuts and almonds. Washington and California together have nearly 32,000 acres of certified organic tree fruits. Over 95% of the organic apple acres in the U.S. are in the Western states. In Washington, organic apple acreage now comprises 10% of all apple acres in the state. The apple variety mix for organic mirrors the conventional mix, with 'Gala' and 'Fuji' the leading varieties and newer varieties such as 'HoneyCrisp' enjoying strong demand. While organic apple prices fell in 2008, sales by Washington fruit companies increased up to 60% over the previous year, and are up again in 2009. This supports the perception that organic apples and other fresh fruits are core purchases for the organic consumer that were not sacrificed during difficult economic times. How much organic fruit and nuts the market can absorb at premium prices remains an open question. But organic price premiums do not guarantee profitability. In a recent organic tree fruit grower survey, 57% of respondents were not profitable with the 2008 crop. They ranked insect pest management as their number one problem and top priority for research. Organic farms offer a "living laboratory" in which management alternatives need to be tried that might not otherwise be considered, absent the constraints of the organic standards. At the same time, conventional and organic pest management for tree crops are converging, and research in organic systems can lead to new practices that benefit all growers, as has occurred with the use of GF-120 for cherry fruit fly control.

115
CONTROL OF DIRECT PESTS OF ORGANIC APPLES: SUCCESSES AND CHALLENGES

Jay F. Brunner and Mike D. Doerr
Washington State University, Tree Fruit Research and Extension Center, Wenatchee, WA 98801

Protection of apples from attack by direct insect pests is in some respects is relatively easy and in others is highly problematic. The key insect pest of apple in the western US is the codling moth, *Cydia pomonella* (L.). This pest has been controlled in most organic orchards due to a combination of tools that when implemented appropriately can resolve even serious problems. Most other Lepidopteran pests, leafrollers, noctuids, leafminers, can also be well controlled in organic apple orchards. San Jose scale can be a serious issue for organic growers if they do not achieve good coverage of the bark in delayed-dormant period with oil treatments. A well managed organic apple orchard will not suffer from economically important outbreaks of aphids or spider mites due to sufficient levels of biological control. However, disruption of biological control can occur with an overuse of certain products. The most serious insect threats to organic apple production come from the Hemiptera, specifically pests such as the mullein plant bug, *Campylomma verbaci* (Meyer-Dür), lygus bug, and stink bugs. No effective management tools are available to protect fruit from attack by these pests. This talk will present reclamation case studies of serious codling moth problems in organic apple orchards, discuss management tools available to organic growers, as well as potential options for dealing with true bug pests.

116
PREDATION OF APHIDS IN ORGANIC PRUNES: HOW MANY PREDATORS ARE ENOUGH?

N. J. Mills
Department of Environmental Science, Policy and Management, University of California, Berkeley CA 94720-3114

Can we rely on natural enemies to provide biological control of secondary pests in organic tree fruit, and if so, how many are needed to provide effective control? While parasitism is easier to monitor, assessing the impact of predators is much more problematic, and yet generalist predators are considered to make important contributions to the natural biological control of secondary pests. One the one hand, experimental approaches based on use of predator exclusion cages have suggested a prominent role for predation, while in contrast, more detailed population and modeling studies have suggested that predators may contribute only minimally. One of the difficulties in quantifying predation on secondary pests (such as aphids and spider mites) in tree fruit is that the dynamics of their populations is characterized by continual recruitment through reproduction and losses from mortality, loss of reproduction, and migration. Consequently, the task of quantifying the role of predation in driving the dynamics of secondary pest populations and assessing how many predators are needed to provide effective control has proved to be very difficult. Here I develop an approach to estimating the impact of predation on secondary pests through a comparison of two quantities; expected losses from predation, based on the density and daily consumption rate of the predators present, and required total losses, based on the extent of mortality required to prevent secondary pest populations from growing. This approach will be illustrated from observations of predation on the mealy plum aphids, *Hyalopterus pruni* Geoffrey in organic prune orchards in California.

117
PEACH ORCHARD GROUND COVER MANAGEMENT MITIGATES BUG DAMAGE

Peter W. Shearer

Oregon State University, Mid-Columbia Agricultural Research and Extension Center, 3005 Experiment Station Drive, Hood River, OR

This work was conducted in New Jersey peach orchards located on grower farms and at the Rutgers Agricultural Research & Extension Center-Bridgeton, in the southern part of the state. The focus of this research was to investigate and demonstrate the impacts of orchard floor management on peach arthropod pests, particularly tarnished plant bug, *Lygus lineolaris*, and the stink bugs, *Acrosternum hilare*, *Euschistus servus* and *E. tristigmus*. These insects are collectively called catfacing insects. Results of this study clearly demonstrate that properly managed peach orchard ground cover reduces catfacing insect pest pressure and subsequent damage to the crop. Peach growers participating in this project had 3 times less damage caused by tarnished plant bug feeding in orchard blocks with managed sod ground covers compared with fruit grown with weedy ground covers or disked orchard floors. Likewise, while testing the suitability of various ground covers and management practices for use in integrated peach production, we collected 3 times more tarnished plant bugs from weedy orchard floors compared with the number found in sod ground covers. Similar reductions in bug abundance and damage were observed in commercial peach orchards planted to sod ground cover following the termination of this research project.

118
ORGANIC STONE FRUIT ORCHARD FLOOR MANAGEMENT: INTERACTIONS AMONG INSECTS, WEEDS, WATER USE, AND CROP NUTRITION AND QUALITY

Diane Alston[1], Andrew Tebeau[1], Jennifer Reeve[2], Brent Black[2], Corey Ransom[2], Marc Rowley[2], Ruby Ward[3], and Silvana Martini[4]

Utah State University
[1]Department of Biology, 5305 Old Main Hill, Logan, UT
[2]Department of Plants, Soils and Climate, 4820 Old Main Hill, Logan, UT
[3]Department of Applied Economics, 3530 Old Main Hill, Logan, UT
[4]Department of Nutrition and Food Sciences, 8700 Old Main Hill, Logan, UT

A group of Utah researchers has initiated an integrated organic peach and tart cherry orchard floor study to optimize management of critical orchard components, including pests, water use, soil health, tree fertility, fruit quality and economics. The project aims to develop sustainable organic stone fruit orchard floor systems adapted to temperate, arid regions of western North America. The entomological objectives will include evaluation of 1) intra- and extra-orchard ground covers, trap crops, and mulches for management of key fruit-feeding insects, such as lygus, European earwig, and cherry fruit fly; 2) organic insecticide programs and their application timing on natural enemy populations and biological control efficiency; 3) extra-floral nectarines of peach and tart cherry on attraction and retention of arthropod pests and natural

enemies in orchards; and 4) a survey of important predators and parasitoids in stone fruit orchards of Utah. The presentation will include a brief literature review of ground cover management in stone fruits and build upon current knowledge to develop organic orchard floor management systems that will optimize fruit production.

119
WHO'S EATING WHOM? EVALUATING PREDATORS AND PARASITOIDS AND THE INFLUENCE OF THE FARMSCAPE USING PROTEIN-MARKING AND GUT CONTENT ANALYSIS

Tom Unruh, Research Entomologist
USDA-ARS Yakima Agricultural Research Laboratory, 5230 Konnowac Pass Rd., Wapato WA
thomas.unruh@ars.usda.gov

Various aspects of agricultural landscapes can enhance or diminish biological control in pome fruit orchards. The major actors in pest suppression in fruit trees may be among the persistent residents of the tree canopy, a few others may colonize the canopy from groundcovers, and many of both of these types may seasonally enter the orchard from surrounding habitats. The value of protein marking techniques and predator gut content analysis in supplementing traditional methods for identifying key natural enemies and evaluating the influence of landscape level influences will be presented.

120
ENHANCING BC IN ORGANIC ORCHARDS USING HIPV LURES TO CHARACTERIZE, MONITOR AND MANIPULATE NATURAL ENEMIES

Vincent P. Jones [1], Shawn A. Steffan [1], David R. Horton [2], Nicholas J. Mills [3], Peter W. Shearer [4]

[1]Washington State University, Department of Entomology,
Tree Fruit Research and Extension Center, 1100 N. Western Ave., Wenatchee, WA
[2]USDA-ARS Yakima Agricultural Research Laboratory,
5230 Konnowac Pass Rd., Wapato, WA
[3]University of California at Berkeley,
Department of Environmental Science and Policy Management, Berkeley, CA
[4]Oregon State University, Department of Horticulture,
Mid-Columbia Agricultural Research and Extension Center, Hood River, OR

The use of herbivore-induced plant volatiles (HIPV's) as monitoring tools allows us to quantify natural enemy phenology, evaluate effects of management actions, and discover which natural enemies are present and abundant in the system. We present data showing how understanding the natural enemy population dynamics can be used and also show why using HIPV's in the whole orchard season-long to increase population levels is likely a very bad idea from the standpoint of population dynamics, biological control, and pest suppression. The use of these compounds is not restricted to organic situations, but is perhaps more critical in those situations to prevent damage from occurring.

SYMPOSIUM: NEW DEVELOPMENTS IN CONTROL TECHNOLOGIES

121
FIRST GENERATION CODLING MOTH CONTROL WITH PROCLAIM SG® (EMAMECTIN BENZOATE)

Christopher Clemens[1] and Roy Boykin[2]

[1] Syngenta Crop Protection, Inc. 2631 Stonecreek Dr. Richland, WA 99354-2140
[2] Syngenta Crop Protection, Inc. 410 Swing Road, Greensboro, NC 27409

Codling moth (CM), *Cydia pomonella* (Linnaeus), is one of the most important apple pests worldwide, and in the Pacific Northwest, it has been the key insect pest since the early 1900s. Growers in WA have available a number of tactics for CM control including pheromone-based mating disruption, Web-based decision assist systems, newer, effective sprayer technologies, and chemical insecticides. Among these chemical insecticides, new highly active, selective active ingredients have been registered over the last 2 years, and these registrations have been timely with the ongoing phase-out of azinphos-methyl (Guthion). Proclaim SG® was registered in WA apples in 2006 for suppression or control of several lepidopteran insect pests, but has been primarily used in WA for oblique banded leaf roller. A Section 2ee label in 2007 followed by a 2008 Section 3 label amendment changed the original Proclaim CM suppression-only claim to control of first generation CM only on apples grown East of the Rocky Mountains. Since then, Proclaim SG has been used successfully on a commercial basis in the East for internal leps when applied at 4.8 oz/A + an adjuvant on a 14 day application interval. These data, as well local small plot data, will be presented. Preservation of CM insecticide susceptibility is important to Integrated Pest Management. Proclaim SG®, a group 6 compound, offers a unique mode of action that will contribute to preservation of insecticide susceptibility as azinphos-methyl is phased out.

122
A LITTLE DAB'LL DO YA: ADVANCES IN FRUIT FLY BAIT TECHNOLOGY WITH SPLAT-MAT™ SPINOSAD ME

Brian L. Bret[1], Luis E. Gomez[1], Agenor Mafra-Neto[2], Roger I. Vargas[3]

[1]Dow AgroSciences, 9330 Zionsville Road, Indianapolis, IN 46268
[2]ISCA Technologies, Inc., 1230 Spring Street, Riverside, CA 92507
[3]US Pacific Basin Agric. Res. Ctr, USDA-ARS, PO Box 4459, Hilo HI 96720

SPLAT-MAT™ Spinosad ME is a joint collaborative effort between Dow AgroSciences, ISCA Technologies, and USDA. SPLAT™ (Specialized Pheromone and Lure Application Technology), the basis of this product, is a novel biologically inert and biodegradable matrix, which imparts long term rain and UV protection for the release of semiochemicals and or pesticides. MAT (Male Attraction Technique) involves the use of methyl eugenol, a naturally occurring substance found in cloves, citrus, and other plants. Methyl eugenol has been identified to be highly attractive to male fruit flies in the *Bactrocera* genus (Oriental fruit fly and Carambola fruit fly among others) from long distances making it suitable for off-crop applications. Spinosad, a fermentation product derived from a naturally occurring soil Actinomycete discovered and developed by Dow AgroSciences, is highly effective against numerous fruit fly species. When SPLAT is formulated with spinosad and an attractant such as

methyl eugenol, the combined MAT technology imparts controlled-release properties protecting them from environmental degradation, attracts male fruit flies, and exposes them to the efficacious control properties of spinosad.

SPLAT-MAT Spinosad ME has been evaluated in several geographies around the world confirming consistent performance across several species of invasive fruit flies. The rainfastness, residual, and attraction properties of the product have been proven to be superior to industry standards. US federal registration of the product was granted in 2008 and the product is expected to be used in conjunction with GF-120® NF Naturalyte® Fruit Fly Bait to replace current organophosphate-based products for Oriental fruit fly control.

® ™ SPLAT is a trademark of ISCA Technologies; GF-120, Naturalyte, SPLAT-MAT Spinosad ME are trademarks of Dow AgroSciences

123

TECHNOLOGY TRANSFER THROUGH THE HAWAII AREA-WIDE PEST MANAGEMENT PROGRAM FOR CONTROL OF FRUIT FLIES IN HAWAII

Roger I. Vargas[1], Ronald F. L. Mau[2], Jaime Pinero[2], and Luc Leblanc[2]

[1]United States Department of Agriculture, Agricultural Research Service Pacific Basin Agricultural Research Center, P.O. Box 4459, Hilo, HI 96720; roger.vargas@ars.usda.gov.
[2]University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources, Department of Plant and Environmental Protection Sciences, 3050 Maile Way, Gilmore Hall, Honolulu, HI, 96822

Melon fly, *Bactrocera cucurbitae* (Coquillett), Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), oriental fruit fly *Bactrocera dorsalis* (Hendel), and Malaysian fruit fly, *Bactrocera latifrons* (Hendel), have accidentally become established in Hawaii, and attack more than 400 different fruits and vegetables. They inhibit development of a diversified tropical fruit and vegetable industry, require commercial fruits to undergo quarantine treatment prior to export, and provide a breeding reservoir for their introduction into other areas of the world. Previous fruit fly control measures relied heavily on organophosphate insecticide applications to crops. In 1999 a 10 yr Area-Wide Pest Management (AWPM) program was initiated for management of fruit flies in Hawaii. The AWPM program integrated two or more control components (field sanitation, protein bait sprays, male annihilation, sterile insects, and parasitoids) into a comprehensive package that has been economically viable, environmentally acceptable, and sustainable. The program resulted in area-wide suppression of fruit flies, a reduction in the use of organophosphate insecticides, and the impetus for further growth and development of diversified agriculture in Hawaii. An important activity of the AWPM program was partnerships with industry and transfer of new technologies immediately to farmers. Among the technologies developed were new monitoring dispensers, reduced-risk bait sprays, and reduced-risk male annihilation applications. These technologies represent some of the most environmentally safe and technologically advanced fruit fly detection and control products ever developed. Permanent registration of these technologies is currently being completed to support sustainability of the program.

124

RECENT INNOVATIONS IN REDUCED-RISK INSECTICIDES FOR PEST MANAGEMENT IN LEAFY VEGETABLES

John C. Palumbo

University of Arizona, Department of Entomology, Yuma Agricultural Center, Yuma, AZ

Leafy vegetable growers have the reputation of delivering high quality produce to the marketplace that is both aesthetically appealing and safe to the consumer. They accomplish this in part by using reduced-risk insecticides to control important insect pests. Recent innovations by the AgChem Industry have resulted in the development of two new classes of insecticide chemistry that possess unique attributes not previously experienced with other reduce-risk products. Chlorantraniliprole (anthranilic diamide, Coragen®) and spirotetramat (ketoenol, Movento™) are two new active ingredients that provide unique modes of action and routes of activity for use in leafy vegetables. These chemical active ingredients are relatively non-persistent in the environment, selectively toxic to specific groups of insects, have low mammalian, aquatic and avian toxicity, and are safe to most natural enemies and pollinators, making them very IPM compatible.

One of the practical attributes associated with these new compounds is their systemic properties that provide flexibility in application for produce growers. As a result of their physiochemical characteristics, the anthranilic diamides have excellent systemic properties (xylem mobile via root uptake) that allow them to be applied in diverse ways such as soil drenches, drip chemigation, and in-furrow soil applications. Chlorantraniliprole, has demonstrated long residual control of *Spodoptera exigua, Trichoplusi ni and Plutella xylostella* larvae and *Liriomyza* leafminers in leafy vegetables when applied exclusively to the soil at planting as an in-furrow application or post-planting through drip irrigation. This selective use of a toxicologically selective insecticide is environmentally sound for leafy vegetable cropping systems. When chlorantraniliprole is applied as a soil treatment, there is minimal exposure to applicators and farm labor.

Spirotetramat was recently registered for use on produce crops and has been readily adopted by desert growers. Although it has no practical soil activity, following foliar application and uptake, the insecticide is fully systemic where it is translocated acropetally and basipetally within the entire vascular system. Research to date has shown excellent residual activity against *Bemisa tabaci* –B biotype, and aphid species such as *Nasanovai ribis nigi* and *Aulacorthum solani* in leafy vegetables that typically require aggressive chemical management for economic control. Because of spirotetramat's foliar, systemic activity, spray coverage with is not as critical as with other contact and translaminar products. This can result in more precise and effective spray timing with aerial applications when irrigation or rainfall prohibits ground applications. The use of these newer, selective compounds in produce crops as already improved insect management in leafy vegetable crops, as well as reduced the risk of exposure to toxic insecticide residues for consumers and farm workers.

125

PYRIFLUQUINAZON – EFFECTIVE NEW CHEMISTRY AGAINST WHITEFLIES

Steven Castle and Eric Hoffmann

USDA-ARS Arid-Land Agricultural Research Center,
21881 N. Cardon Lane, Maricopa, AZ 85138

Pyrifluquinazon is a new insecticide developed by Nihon Nohyaku Co. Ltd in Japan with an unknown mode of biological activity. It is still in an experimental stage with an anticipated EPA registration in 2011-12. In addition to being an effective whitefly material, pyrifluquinazon has demonstrated good activity against other hemipteran plant feeders including certain species of aphids, mealybugs and scale insects and against thrips as well. Against the sweetpotato whitefly *Bemisia tabaci*, pyrifluquinazon has proven highly toxic based on leaf bioassays in clip cages (LC_{50} < 0.1 ppm) and contact bioassays in coated glass vials. This insecticide is often presented as a behavior modifying compound that causes cessation of feeding and is similar to the effects observed with pymetrozine. However, observations of *B. tabaci* adults exposed to pyrifluquinazon indicate that effects are much more systemic in the insect than just affecting feeding. Afflicted insects are apparent within 1 h of contact exposure and manifest an inability to coordinate muscles in order to maintain an upright position. By 24 h, >95% of test insects are dead and desiccating. Given the relatively rapid impact on whitefly feeding and other muscle-coordinated behaviors, pyrifluquinazon has shown itself as a candidate insecticide for disrupting virus transmission by whiteflies. Since virtually all plant viruses transmitted by *B. tabaci* are phloem-limited viruses, the prolonged time often required for whitefly mandibular stylets to attain the phloem will potentially provide sufficient time for pyrifluquinzon to interfere with feeding behavior prior to introducing virus to the phloem, thus preventing transmission. In greenhouse studies examining transmission of *Cucurbit yellow stunting disorder virus* (CYSDV) to young cantaloupe plants, foliar treatment rates of 62.5 and 125 µl ml^{-1} of formulated product (20SC) proved highly effective at reducing transmission of CYSDV. The translaminar activity of pyrifluquinazon provided good residual activity that was effective at preventing transmission to the same set of test plants when challenged a second time by three different whitefly densities 3, 10, 30). Pyrifluquinazon represents a promising new chemistry with a probable unique mode of action that will represent a very effective compound to be used in rotation with other newer insecticides for managing *B. tabaci.*

126

ESTABLISHMENT OF BASELINE TOXICITY DATA AGAINST KEY AGRICULTURAL PESTS: A COMPONENT OF SUSTAINABLE MANAGEMENT

Nilima Prabhaker

University of California, Riverside

The tetronic and tetramic acid derivatives, also known as keto-enols, represent a new class of insecticides introduced into integrated pest management programs during the past 3-4 years. This group is currently represented by the insecticides spiromesifen, spirotetramat and spirodiclofen that provide effective control of a fairly broad spectrum of sucking insects and mites. The efficacies of spiromesifen and spirotetramat were tested against a number of field populations of B-type whiteflies, *Bemisia argentifolii*, and vine mealybug, *Planococcus ficus*, to establish a baseline prior to commercial registrations. These baseline values will serve as valuable reference points by which populations of both species will be evaluated for resistance development. Laboratory bioassays against natural populations of *B. argentifolii* from Arizona and California using a leaf spray method revealed a range of responses towards susceptibility to both compounds. The range of LC_{50}s among populations in response to spiromesifen and spirotetramat, respectively, were 0.210 - to 6.08 and 0.912- to 27.98 (µg/ml). The sensitive responses of *B. argentifolii* from the Southwest region to spiromesifen and spirotetramat indicate that both compounds are very effective at present. However, resistance can develop in *B. argentifolii* to these compounds after long-term exposure. Therefore, we also evaluated potential cross-resistance patterns to the two compounds in imidacloprid, bifenthrin and pyriproxyfen-resistant whitefly strains. No cross-resistance was detected to spiromesifen or spirotetramat in the resistant strains.

Ten populations of field-collected *P. ficus* from California were bioassayed with spirotetramat to establish a geographic baseline data for comparison of future population responses to spirotetramat. A leaf spray method was used to assess toxicity to spirotetramat in vine mealybug populations and this method will form the basis of continuing and future resistance monitoring. All ten populations of mealybugs showed high levels of susceptibility to spirotetramat with LC_{50}s ranging from 3.46 – 13.27 (µg/ml). Results show that spirotetramat, first registered for use on grapes in 2009, may be valuable for the management of *P. ficus*, especially in situations where local strains may be resistant to other commonly used insecticides.

A greenhouse strain of Banks grass mite, *Oligonychus pratensis* (Banks) was evaluated for its susceptibility to spirotetramat and spirodiclofen. The LC_{50} s were low at 6.24 and 12.50 (µg/ml) to spirotetramat and spirodicolfen respectively, indicating that the two keto-enols are very effective against *O. pratensis*. The present study indicates that the introduction of keto-enols with a novel mode of action will aid in combating resistant pest species and sustain agricultural productivity.

127
NEW PESTICIDES FOR TREE FRUIT: SAFER FOR WHOM?

Elizabeth H. Beers
Washington State University, Tree Fruit Research and Extension Center,
1100 N. Western Ave., Wenatchee, WA

Recent changes in pesticide legislation have been aimed at promoting "reduced risk" pesticides for better worker safety; however, some of these materials have an extensive array of nontarget effects on beneficial arthropods. Forty years of organophosphate and carbamate use in Washington's tree fruit IPM systems produced a relatively stable system for chemical control of primary pests, and biological control of secondary pests. The transition to new insecticides, especially for the key pest codling moth, has destabilized the control for indirect pests. Unlike the pesticides that preceded them, the newer materials are less likely to have high levels of contact toxicity, but sublethal effects can severely suppress life history parameters such as prey consumption, fecundity, and egg viability. Examples of nontarget effects from bioassays and field plots are presented for two indirect pests of apple, spider mites and woolly apple aphid.

128
SEED TREATMENT AND COATING TECHNOLOGIES FOR EARLY SEASON PROTECTION

Alan Taylor
Department of Horticultural Sciences, NYSAES, Cornell University,
630 W. North Street, Geneva, NY 14456

Seed treatments have many applications in agriculture and this trend is growing, as seeds are the carrier or delivery system for materials required to protect them at time of sowing. Coating technologies are needed for application of high loading rates of seed treatment insecticides that cannot be accomplished by conventional slurry methods. The Seed Science and Technology lab at Cornell's Geneva campus specializes in seed coating technologies using rotary pan technology for film coating or encrusting. Film coating is a technique originally developed for the pharmaceutical and confectionery industries to produce a colored, exterior finish. This method was adapted for seed coating, whereby a liquid formulation that includes a film-forming polymer is sprayed at a controlled rate onto a tumbling mass of seeds over time, while drying air passes over the seeds during spraying. Formulations may also contain plasticizers, colorants and other ingredients that are commercially available in aqueous suspensions. The benefits of film-coating include uniform placement of materials in the correct dosage, increased worker safety (an essentially dust-free environment), enhanced appearance due to the addition of pigments and an excellent delivery for seed treatments at rates higher than those allowed using slurry techniques. Film coating is routinely performed by the seed industry on high-value seeds such as vegetables and flowers. A modification of film coating is the addition of conditioning or drying powders to reduce the drying time during coating and resulting in a build-up of material called encrusting.

The early development of Spinosad as a commercial seed treatment will be presented with the partnering of Cornell, IR-4 and the Ag and Seed Treatment industries. Research on onion

(*Allium cepa*) seed treatments will be highlighted. The application rate of 0.2 mg ai spinosad is applied per seed resulting in about a 10% weight increase due to seed treatment plus coating formulation. Management of the soil insect, onion maggot, *Delia antiqua* with Spinosad was comparable or better than other industry standards, cyromazine seed treatment or an in-furrow drench of chlorpyrifos. Seed treatments results in about a 90% reduction in pesticide usage compared to the in-furrow treatment. Research was conducted with Spinosad as a seed treatment on other vegetable seeds, thus expanding the label for below ground pest management. Moreover, a label for the OMRI approved Entrust formulation permits this seed treatment for organic production.

Several non-traditional crops are under investigation that have potential suitable for biofuel production. There is a need for high quality seed lots that will produce optimum plant stands with the potential for maximum biomass production. Seed dormancy, suboptimal soil conditions, and pests often lower seed quality and can negatively impact stand establishment. No seed treatments are labeled for oil seed crops such as pennycress (*Thlaspi arvense*) that may be used for biodiesel production, while there are only a few fungicides including Captan, Thiram and Metalaxyl for warm-season grass biofuel crops. Seed technology and seed coating methods were developed to apply more uniform and adherent seed treatments to the waxy covering layers of switchgrass (*Panicum virgatum*). A seed coating method was developed including seed conditioning by brushing seeds to remove glumes, and then application of a special seed coating binder and filler to obtain uniform application. Combinations of selected insecticide and fungicide seed treatments enhanced stand establishment.

129
NEONICOTINOIDS, PACKAGE MIXES, RESISTANCE, INTEGRATED PEST MANAGEMENT AND THE PACIFIC NORTHWEST POTATO MARKET

Alan Schreiber

Agriculture Development Group, Inc., 2621 Ringold Road, Eltopia, WA99330

Almost one out of five insecticides registered on potatoes in the Western U.S. contain a Group 4a neonicotinoid. The leading neonicotinoid, imidacloprid, has recently become generically available. As a result of this, the number of products containing the active ingredient has greatly increased and have become exceedingly cheap. The price of imidacloprid in the potato market has fallen by 90% from its introduction 15 years ago. The class of chemistry is very effective, consistent in performance and now is very cheap, making Group 4 products very attractive to the grower. The number of pre mix insecticidal products registered on potatoes has increased from 1 to six since 2008; all of these products contain a pyrethroid or neonicotinoid. There is tremendous pressure to sell large volumes of both types of chemistries into an industry that has largely escaped development of insecticide resistance. The confluence of generification of neonicotinoids, widespread introduction of insecticidal package mixes, collapse of the pricing structure for potato insecticides and the economic straits of the potato industry in the Pacific Northwest is threatening the delivery of integrated pest management programs and poses significant risk the susceptibility of important potato insect pests.

SYMPOSIUM: THRIPS BIOLOGY, CONTROL, AND RESISTANCE MANAGEMENT

130
ONION THRIPS CONTROL ON DRY BULB ONIONS IN WASHINGTON STATE

Tim Waters, WSU Extension, 1016 N. 4th Ave. Pasco, WA
Doug Walsh, WSU Department of Entomology, 24106 N. Bunn Rd Prosser, WA

Thrips infestations are a perennial, persistent and ubiquitous problem throughout Pacific Northwest dry bulb onion fields. Several species of thrips have been found in the Columbia Basin, but the prevalent pest species on onion are onion thrips, *Thrips tabaci* Lindemann, and Western flower thrips, *Frankliniella occidentalis* (Pergande). Both species can negatively impact onion bulb size and storage stability. Where the two species differ is in their potential threat to onion crops. Onion thrips vector a Tospovirus, Iris Yellow Spot Virus making them the greater of two evils. Few insecticides are effective at controlling thrips, and in onions several insecticide applications are required annually to reduce thrips numbers to a tolerable level. Thrips are susceptible to developing resistance to insecticides, and onion thrips resistance to pyrethroid insecticides has been documented in areas of the Pacific Northwest. Studies were conducted to evaluate current pest management practices. Specifically, we evaluated different sequences of insecticide applications for efficacy in controlling thrips and subsequent yield and size profile of onions achieved from the various control schemes. In addition, seasonal population dynamics and proportion of onion thrips to Western flower thrips were recorded for two seasons in onion fields in Washington State. We determined that narrow range insecticides were best used early in the season, while broad spectrum insecticides were best utilized later in the growing season. Thrips populations peaked in onions in early July both seasons, and consist primarily of onion thrips.

131
DEVELOPING AN IPM PROGRAM FOR THRIPS PESTS OF TIMOTHY (*Phleum pretense* L.) IN THE WESTERN U. S.

Larry Godfrey[1], Dominic Reisig[1], Dan Marcum[2]

[1]University of California, Dept. of Entomology, One Shields Ave., Davis, CA 95616
[2]Cooperative Extension Shasta County, Shasta-Lassen Office,
P.O. Box 9, 44218 A Street,
McArthur, CA 96056-0009

Hay from cool-season grasses, particularly timothy, is an important crop in several western states. Production of this grass hay is highly valued as feed for horses (race horses and hobby farms) and it is also commonly expored; prices for "good quality" timothy hay have remained consistently strong and are often 25% above that for alfalfa hay. Marketing of cool-season hay is based largely on visual appearance and aesthetics of the crop. Green color, long inflorescences, and high leaf to stem ratio are favorable characteristics. In recent years, grass thrips (*Anaphothrips obscurus*) and mites (several species but primarily *Tetranychus* spp. and *Oligonychus* sp.) have caused severe damage to cool-season grass crops in California. Pest

management studies in cool-season grasses are very limited. As the crop acreage, the market demands, and importance to the local agricultural economies all increase, the needs for and scrutiny of sound integrated pest management practices have also increased in the crop. Studies conducted in grower timothy fields in northern California from 2005 to 2008 examined thrips species distribution, thrips population dynamics, sampling protocols, decision thresholds, influence of cultural practices on pest populations, insecticidal control measures, and effects of control measures on populations of secondary pests. In addition, the effects of nitrogen level and population density on incidence of thrips morph (wing dimorphism) was evaluated in a field study.

132
THE ONLY PLACE IN THE WORLD WHERE THRIPS ARE A PEST OF POTATOES IS IN THE COLUMBIA BASIN

Alan Schreiber

Agriculture Development Group, Inc., 2621 Ringold Road, Eltopia, WA 99330

Western flower thrips are a pest of potatoes only in the Columbia Basin of Washington and Oregon. While the species is not known to vector diseases in potatoes, their feeding results in a reduction in the photosynthetic capability of the plants. Each year thousands of acres are treated with relatively potent insecticides to control the pest. The insect species has only recently been identified as a pest of potatoes probably due to a shift in insect management programs, most notably a reduction in use of carbamate and organophosphate insecticides. Little is known of their biology on potatoes. No economic thresholds or economic injury levels exist for potatoes. Control is achieved exclusively through use of insecticides and the main product used for thrips control, methamidophos is being removed from the market place. The loss of this product has created significant anxiety in the potato crop protection and grower community.

133
SUPPRESSION OF ONION THRIPS EGG LOAD IN PLANTS AND INFLUENCE OF ONION CROP MANAGEMENT PRACTICES ON THRIPS AND IYSV

Diane Alston[1], Jennifer Reeve[2], Daniel Drost[2], Kristie Buckland[2], and C. Kent Evans[3]

Utah State University
[1]Department of Biology, 5305 Old Main Hill, Logan, UT
[2]Department of Plants, Soils and Climate, 4820 Old Main Hill, Logan, UT
[3]USDA ARS, Pullman, WA

Short-term suppression of thrips adult and larval populations with contact insecticides has been the primary control strategy used in onion production for decades. Problems with development of insecticide resistance in the thrips population, the need for numerous insecticide applications per season, high cost, inadequate control, and off-target effects have plagued this management strategy. We have investigated longer-term thrips suppressive strategies, including crop and pest management tactics that reduce thrips reproduction and egg viability, and decrease the incidence

and severity of the iris yellow spot virus, IYSV. Whole-plant onion samples from commercial fields have demonstrated that eggs compose the majority of the thrips population on plants, 60-75%, and eggs are the main life stage contributing to significant plant infestation. Therefore, reducing the thrips egg load in plants should result in more sustainable and longer-lasting thrips suppression. Applications of systemic insecticides, management of crop nitrogen levels in soil and onion plants, and intra-planting attractive trap crops were investigated for their effects on reducing numbers of thrips eggs and motile life stages, and decreasing the incidence and symptoms of IYSV. Some systemic insecticides decreased the number of eggs laid and the hatch of viable larvae from treated plants. Some fields with lower nitrogen levels were associated with reduced need for insecticide applications, lower thrips densities, and less IYSV. We hypothesize that managing crop nitrogen may promote plant tolerance or reduce plant attractiveness to onion thrips. Lacy phacelia and carrots were more attractive to thrips in the early season, but as onion growth advanced, more thrips were found on onions than on trap crops. Larger plots and successive plantings of trap crops to provide highly attractive growth stages over a greater temporal period may enhance the efficacy of trap crops for onion thrips.

134
THRIPS-TRANSMITTED TOSPOVIRUSES: IS THERE A WAY TO BREAK THIS ALLIANCE?

Hanu R. Pappu

Department of Plant Pathology, Washington State University, Pullman, WA 99164

Tospoviruses cause significant losses to the quality and yield of numerous vegetables, legumes and ornamentals in many parts of the world. World-wide annual losses due to these viruses are estimated over US $1 billion. The group's name was derived from its most prolific member, *Tomato spotted wilt virus*. There are more than 20 different tospoviruses are described to-date. Unlike many other plant viruses that are transmitted through seed, tospoviruses are exclusively transmitted by thrips and are not seed-transmitted. Thus, thrips play a critical role in the tospovirus epidemiology. About ten different thrips species have been shown to vector tospoviruses. One of the most prolific thrips species implicated in tospovirus outbreaks is western flower thrips, *Franklienella occidentalis* which can transmit multiple tospoviruses. In the Pacific Northwest (PNW), besides WFT, another major tospovirus vector species is the onion thrips, *Thrips tabaci*. *T. tabaci* is a vector of *Iris yellow spot virus*, causal agent of a severe disease in onion bulb and seed crops in the PNW for the last several years. High populations of onion thrips, availability of a relatively few insecticides to manage them, the overlapping nature of the bulb and seed onion crops providing green bridge for both the virus and the thrips vector may have contributed to the continuing outbreaks of this thrips-transmitted tospovirus in onion in PNW. The uniqueness of thrips-tospovirus association is that the virus multiplies in its thrips vector. The virus has to be acquired by first or second instar larva, the virus survives through the subsequent developmental stages and the adult thrips becomes viruliferous (=capable of transmitting the virus to other plants during the process of feeding). Adult thrips that happen to feed on a virus-infected plant could acquire the virus but cannot transmit. This was shown to be due to the presence of a midgut barrier in the adult thrips. Since the virus multiplies in the insect vector with almost equal efficiency as it does in its plant hosts, the virus effectively enjoys two

disparate reservoirs for its survival. Due to the critical role that thrips play in tospovirus outbreaks, considerable research effort has been ongoing in several countries to better understand the basis of the tospovirus-thrips interactions at the genetic, physiological and molecular levels with an aim to utilize this information for developing management programs that would reduce the virus outbreaks. New tools for rapidly identifying thrips that are carriers of the virus are developed. These methods have the potential in determining the seasonal dynamics of virus carriers and utilize this information in refining thrips control practices to reduce final disease incidence. Thrips transcriptome is being deciphered and genes and pathways that are critical in thrips development are being identified. These could be potential targets for interfering in thrips development and thus interfering with virus transmission as well as achieving thrips control.

135
INSECTICIDE RESISTANCE MANAGEMENT IN THRIPS: A MAUFACTURER'S PERSPECTIVE

Harvey A. Yoshida[1], James E. Dripps[2], Michael M. Lees[3], James P. Mueller[4] and Anthony W. Weiss[5]

[1]Dow AgroSciences, 432 Aimee Drive, Richland, WA 99352
[2]Dow AgroSciences, 9330 Zionsville Road, Indianapolis, IN 46268
[3]Dow AgroSciences, 5200 Parkford Circle, Granite Bay, CA 95746
[4]Dow AgroSciences, 175 Mesquite Court, Brentwood, CA 94513
[5]Dow AgroSciences, 804 River Hammock Blvd, Brandon, FL 33511

Thrips are key pests of numerous agricultural and ornamental crops worldwide causing direct feeding damage and vectoring viruses. Chemical control is a tactic commonly used against thrips; however, numerous factors pose significant challenges to insecticide resistance management programs. Long growing seasons, proximity of alternate host plants, lack of alternative management options and the profitability of high quality fruits, flowers and produce have placed significant emphasis on insecticides for thrips control. In addition, the lack of effective rotation partners has led to the misuse of available insecticides to the point where discernible shifts in susceptibility have been documented.

Proactive resistance management measures such as label restrictions and end user outreach efforts alone may not be effective in preventing resistance development. Significant capital and resources are needed to monitor and track shifts in high-risk market segments. In rare instances reactive measures such as product use restrictions have been implemented to curtail the progression of resistance. Manufactures make large investments in the discovery and registration of new modes of action; therefore, understanding grower's needs, availability of effective non-chemical options (e.g. biological and cultural control), market trends and the mechanism of resistance are just some of the factors that must be considered to sustain the long term viability of insecticide products for thrips.

136
MANAGING ROTATION OF BIO PESTICIDES TO CONTROL ONION THRIPS IN EASTERN OREGON

Silvia I. Rondon[1]

[1]Oregon State University, Hermiston Agricultural Research and Extension Center, PO Box 105, Hermiston, OR

Onion thrips, *Thrips tabaci* Lindeman, is a polyphagous pest that causes serious damage on vegetables and ornamentals around the world especially on Alliaceae plants such as onions (*Allium cepa* L.). Thrips-transmitted *Iris yellow spot virus* (IYSV), first found in the Treasure Valley of Idaho in the early 1990s, has spread rapidly across the western USA and is causing economic impact on both seed and bulb onion production. Despite intensive insecticide use (>8-10 applications) for management of onion thrips, control remains difficult. In this context, effective rotational adaptation of biopesticides with conventional pesticides for thrips management in onion would be a breakthrough in onion production. In 2008 and 2009, populations of the onion thrips were evaluated weekly, and numbers were used to determine spray schedules. Two plants per experimental unit were removed, bagged, and transferred on a weekly basis to the entomology laboratory where thrips were counted. Products were rotated by mode of action to reduce the potential for the development of resistance. Same rotations were followed both years. Several biological pesticides rotations significantly reduced thrips numbers.

137
INVESTIGATING ALTERNATIVES TO TRADITIONAL INSECTICIDES: THE EFFECTIVENESS OF FUNGI AND *BT* AGAINST CITRUS AND AVOCADO THRIPS

Deane K. Zahn and Joseph G. Morse

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

Citrus thrips, *Scirtothrips citri* (Moulton), is a plant-feeding pest most widely recognized for damage caused to citrus and mango fruits and it has recently broadened its known host range to become a significant pest of California grown blueberries. Avocado thrips, *Scirtothrips perseae* Nakahara, is a recently invasive pest of California avocados. Effective alternatives to traditional pesticides are desirable to reduce impacts on natural enemies and broaden control options in an effort to minimize pesticide resistance via rotation of control materials. In the laboratory, we evaluated *Bacillus thuringiensis* (*Bt*) proteins Cyt 1Aa and Cyt 11Aa in two forms, (activated and inactivated) and multiple strains of *Beauveria bassiana* (Balsamo) against both species of thrips. The six *B. bassiana* strains were tested at four concentrations and log-probit analysis generated LC_{50} and LC_{95} values but χ^2 analyses did not result in any significant differences between any of the strains for avocado thrips, however, there were significant differences found for citrus thrips. The performance between strains can be rated based upon the LC_{50} and relative linearity of the response line. Neither activated or inactivated forms of either *Bt* proteins (Cyt 1Aa and Cyt 11Aa) resulted in thrips mortality for either species. Further results for the two *Bt* proteins and the six *B. bassiana* strains will be discussed for each species.

138

BEHAVIOR AND DEVELOPMENT OF THE WESTERN FLOWER THRIPS, *FRANKLINIELLA OCCIDENALIS*

Urs Wyss[1], Michael Parrella[2] and Harvey Yoshida[3]

[1]Institute of Phytopathology, University of Kiel, Germany
[2]Department of Entomology, University of California, Davis
[3]Dow AgroSciences, Richland, WA

Using remarkable macro-photography, the world of the western flower thrips is revealed in stunning detail and clarity. The following aspects of its biology are expanded in this video presentation: feeding on pollen grains, feeding on leaf tissue, clean/preening, mating, egg laying in a leaf and in a leaf vein, egg hatching, development through all instars including each molting event, intraspecific interactions and defensive behavior against predatory mites. Please go to Dr. Wyss's web site for (EntoFilms) for information about this video and others focusing on arthropods.

http://www.entofilm.com/index_en.php?UID=WJZ7aibSggKNzHRL49tR9yPDUrPmxS194524823

JOHN HENRY COMSTOCK AWARD-WINNER PRESENTATION

DEVELOPING SUSTAINABLE IPM PROGRAMS FOR TREE FRUITS USING REDUCED-RISK INSECTICIDES

Ashfaq A. Sial

Washington State University, Tree Fruit Research and Extension Center, Wenatchee, WA 98801

Historically, broad-spectrum insecticides have been the primary tools to manage insect pests in tree fruits. Although insecticide use has decreased with the introduction of synthetic pheromones, tree fruits are still one of the most pesticide-intensive crops. Market's low tolerance for insect and disease injury due to consumers' demand for virtually blemish-free fresh fruits seems to be the major driver. Use of broad-spectrum insecticides, such as organophosphates (OPs) for decades has led to the development of OP resistance and cross-resistance to other classes of insecticides in major pests. In addition, regulatory actions, such as the Food Quality Protection Act of 1996 (FQPA) have put restrictions on the use of broad-spectrum insecticides leading to OP phase-out. The development of insecticide resistance and implementation of FQPA along with restrictions in international markets have led to the development of more environmentally friendly chemicals, such as chlorantraniliprole and spinetoram. With the availability of these products, it was critical for tree fruit growers to incorporate the reduced-risk insecticides into IPM programs. However, very little information was available to growers on how to utilize these products in IPM programs in a sustainable manner.

With that in mind, studies were initiated to look at lethal and sublethal effects, stage-specificity, and residual efficacy of these chemicals using obliquebanded leafroller (OBLR), *Choristoneura rosaceana* (Harris) (Lepidoptera: Tortricidae) as a model species. Field populations were tested to establish the baseline susceptibility, and a laboratory population was selected for resistance to assess the risk of resistance evolution and determine possible resistance mechanisms. These investigations revealed that chlorantraniliprole and spinetoram have strong lethal as well as sublethal effects. They were equally effective against OBLR larvae of all ages and have very long residual activity. However, evidence of resistance and cross-resistance in the field as well as development of resistance in response to laboratory selection indicates that the risk of resistance evolution against these chemicals exists. Studies also showed that in the absence of selection populations reverted to being susceptible and that different detoxification systems were involved with each chemical. This latter fact indicates that chlorantraniliprole and spinetoram could be effectively incorporated into resistance management programs through strategies of rotation. Implementation of such strategies at this point would be a proactive approach and would lead to management of insect pests of tree fruits on a sustainable basis. Incorporation of new reduced risk insecticides into tree fruit IPM programs represents a major change that creates a safer work environment but concerns regarding their negative effects on natural enemies shown by some of the recent studies raise additional questions on how best to integrate their use into such programs.

TUESDAY NIGHT PLENARY SESSION

ECONOMIC SUSTAINABILITY IN THE EVOLVING WORLD: IMPLICATIONS FOR AGRICULTURE AND THE ENVIRONMENT

Steven C. Blank
Agricultural Economist, University of California, Davis

Both natural and social scientists have been focusing much attention on a new issue over recent years: "sustainability." In American agriculture, the discussion became more intense in 1990 when Congress passed a "Farm Bill" that defined "sustainable agriculture." Parts of that definition included the requirements of "economic viability" and enhanced environmental quality for true, long-run sustainability, thus linking the work of social and natural scientists in the quest for a production system that will serve both present and future generations. This presentation will summarize the evolution of agriculture to its current competition with environmental issues and suggest how this conflict might be turned into a complementary coexistence. American agriculture's current struggle for profitability is shown to be a driver of the conflict, whereas growing public concerns for environmental issues offer an opportunity for social and natural scientists to jointly derive a sustainable solution.

SECTION II: POSTER PRESENTATIONS

STUDENT COMPETITION POSTERS: UNDERGRADUATE

1SPO
THE EFFECT OF AGE ON THE EGG-LAYING CAPACITY OF ONION THRIPS

Lincoln Andreasen and Diane Alston
Utah State University, Department of Biology, 1400 Old Main Hill, Logan, UT 84322-1400

The purpose of this project was to observe the effect of age on the egg-laying capabilities of onion thrips. Thrips were transferred from an onion field in Kaysville, UT to the lab. An indoor colony of onion thrips was established on lima bean plants. Nine seven-day trials of newly emerged adult thrips and one week-old adult thrips were conducted on single lima bean leafs in small, sealed petri dishes. The number of hatched immature thrips and eggs laid in the leaf were recorded to compare reproductive success. It was found that "New" adults laid slightly more eggs on average than "Aged" adults. This result was somewhat unexpected as it went contrary to the initial hypothesis that older adults would lay more eggs than newly emerged adults.

2SPO
PHEROMONE MATING DISRUPTION OF *CYDIA LATIFERREANA* (TORTRICIDAE), FILBERTWORM MOTH, IN COMMERCIAL HAZELNUT ORCHARDS

Christopher Hedstrom[1], Vaughn Walton[2], Ute Chambers[3]
[1] Department of Bioresource Research, Oregon State University, Corvallis, OR 97331
[2]Department of Horticulture, Oregon State University, Corvallis, OR, 97331-7304
[3]Tree Fruit Research and Extension, Washington State University, Wenatchee, WA 98002

Oregon supplies the United States with nearly 100% of its hazelnuts. Currently, the key pest threatening commercial hazelnut orchards in Oregon *is Cydia latiferreana* (Tortricidae), filbertworm moth (FBW). The current method of control for this pest is applications of Esfenvalerate (Asana XL), a broad-spectrum pyrethroid. Based on the success of using pheromone mating disruption to control *Cydia pomonella*, codling moth, a taxonomically related generalist pest, it was hypothesized that similar methods could be used to control FBW. One of two field research seasons was completed during Summer 2009. A synthetic pheromone was tested in commercial hazelnut orchards located in the Willamette Valley of Oregon. Ring and twin-tube dispensers containing synthetic FBW sex pheromone were placed in two orchards at three densities (high, low, and untreated control). Sticky traps containing septa of synthetic sex pheromone at two strengths (1x and 10x) were placed in each test plot. Traps containing live female FBW adults were placed in each test plot to monitor for behavior change in adult male moths. Based on the first set of data, mating disruption by use of synthetic pheromone shows promise but is still inconclusive. Sticky trap counts suggested that the pheromone might have influenced behavior change in males. Hazelnuts from the test plots were examined for FBW infestation, which was less <1% in all test plots.

3SPO
INVESTIGATING THE ENDEMICITY OF *APHONOPELMA* SPECIES (ARANEAE: THERAPHOSIDAE) IN CALIFORNIA'S SOUTHERN COAST RANGES

Clay Gunnell, Joseph Wilson, and James Pitts
Department of Biology, Utah State University, 5305 Old Main Hill, Logan, UT 84322

Tarantulas are the largest terrestrial arthropod in North America, but their taxonomy is in complete disarray. In California's Southern Coast Ranges there are supposedly four species of tarantulas (*Aphonopelma spp.)* that are highly endemic. Given that *Aphonopelma* are notoriously difficult to identify we wanted to determine how many species occur in the Southern Coast Ranges and determine endemicity using molecular techniques. This was done by collecting specimens from many locations along the Costal Ranges and the foothills of the Sierra Nevada's. The gene Cytochrome Oxidase I (CO1) was amplified for each specimen and these sequences were analyzed using Bayesian techniques. Bayesian analysis suggests that only a single species lives in the Southern Coast Range, and we conclude that the four historical Southern Coast Range species are synonymous. This analysis also suggests that two unrelated species occur in the Sierra Nevada Mountians. However, it is unknown where or not these species are described and these species must be further investigated.

4SPO
THE MOLECULAR IDENTIFICATION OF BEETLE PEST LARVAE

Sarah Maxfield-Taylor[1], Sujaya Rao [1], Aaron Liston [2], Todd Temple [2]
[1] Oregon State University, Department of Crop and Soil Science, 3017 ALS, OR, 97331
[2]Oregon State University, Department of Botany and Plant Pathology, Corvallis, OR, 97331

Today's advances in molecular biology enable us to conduct research at levels that were impossible earlier. One unexploited area is the use of molecular techniques for pest identification. While damage is often caused by immatures, pest identification is based on adult characteristics. Immatures of related species often resemble each other, and have to be reared to be identified, which can take a year--during which the insects may die. Also, rearing protocols are not available for many pests. Consequently, insecticides are applied for insects that are considered to be pests, even though they do not cause damage.

The objective of this study was to identify a molecular marker for separation of the larvae of three beetle pest species, *Sphenophorus parvulus* (The Bluegrass Billbug), *Sphenophorus cicatristriatus* (The Rocky Mountain Billbug) and *Sphenophorus sayi,* which have been detected in fields of Kentucky bluegrass in eastern Oregon. Based on reports from other regions, the Bluegrass and Rocky Mountain billbugs have the potential to cause major economic damage to eastern Oregon's grass seed industry. There is no information on the impact of *S. sayi*.

In this study, adults were subjected to DNA extraction, amplification, and sequencing. Using BioEdit, a comparison was made of sequenced data from the conserved mitchochondrial cytochrome c oxidase subunit 1 area of all three species for detection of polymorphic regions that can be used for species separation. Results of the use of the markers for billbug larvae identification will be presented along with additional applications for the use of molecular markers for applied entomological research.

STUDENT COMPETITION POSTERS: MASTER'S

5SPO
IS *SPHAEROPTHALMA AROTA* (HYMENOPTERA: MUTILLIDAE) A SINGLE SPECIES? BIOGEOGRAPHY AND SYSTEMATICS OF A CRYPTIC SPECIES-COMPLEX

Sarah Clark, Joseph S. Wilson and James P. Pitts
Department of Biology, Utah State University, Logan, UT 84322

We investigated the phylogeographic structure of *S. arota* from sites across the western Nearctic including the three deserts and several arid regions. The rDNA internal transcribed spacer regions (ITS1 & ITS2) were amplified and analyzed for phylogeographic structuring. Bayesian analysis of the 1,715 base pair region revealed *S. arota* is a complex of four clades. Differences in genetic distance suggest that these clades are different species. Suitable morphological characters could not be found to separate these four species. Thus, *S. arota* is a cryptic species complex. These species show a biogeographical pattern. 'Species A' inhabits the western Sonoran Deserts, 'Species B' inhabits the Madrean Archipelago, 'Species C' is widespread inhabiting the Chihuahuan, Mojave, and eastern Sonoran Deserts and Colorado Plateau, and 'Species D' inhabits the Californian Mesic region. Populations within 'Species C' show a phylogeographic pattern. Ecological niche modeling was used to determine suitable habitat for the species.

6SPO
NATURAL ENEMIES OF *GLUPHSIA SEPTENTRIONIS* WALKER (LEPIDOPTERA: NOTODONTIDAE) ON THE PACIFIC NORTHWEST HYBRID POPLARS

Alejandro I. Del Pozo, R. Andrew Rodstrom and John J. Brown
Washington State University, Department of Entomology, Pullman, WA

As part of the lepidopteran defoliator complex in the Pacific Northwest hybrid poplars, *Gluphisia septentrionis* Walker can cause severe defoliation of poplar trees. Those areas attacked by *G. septentrionis* can be treated with pesticides such as Indoxicarb which provides excellent control. In 2009 season, it was reported that *G. septentrionis* had only one damaging generation, instead of two generations per year. It is proposed that a complex of natural enemies diminished the *G. septentrionis* population during 2009. This complex is composed by: an egg parasitoid (*Trichogramma sp.*), a larval parasitoid (*Eulophus orgyiae* Fitch), a predator of larva (a species of Pentatomidae family), and a Dipteran parasitoid of pupae (a species of Tachinidae family). Data collected in 2009 from field surveys in July and August showed that *G. septentrionis* larvae were parasitized at a rate of 25%; and 85% of its eggs were parasitized. The monitoring of *G. septentrionis* populations in hybrid poplars during 2010 will reveal when the first adult emergence occurs, an event needed to develop a degree day model. In order to improve pest management strategies on hybrid poplar plantations, we need to be able to predict pest emergence and monitor pest populations.

7SPO
OCCURRENCE AND LARVAL DEVELOPMENT OF NOCTUID PESTS ON POTATOES

Dax Dugaw[1], Peter J. Landolt[2], Andrew Jensen[3], Alan Schreiber[4], Richard S. Zack[1]
[1] Washington State University, Department of Entomology, Pullman, WA
[2] USDA-ARS Yakima Agricultural Research Laboratory, Wapato, WA
[3] Washington State Potato Commission, Moses Lake, WA
[4] Agriculture Development Group Inc., Eltopia, WA

Caterpillars of a number of species of moths can infest and defoliate potato plants, causing economic damage, primarily through loss of plant vigor. These include cutworms, loopers, and armyworms. There is little or no information on the abundance, pattern of occurrence, host suitability, economic threshold or other basic information on these pests. Our goals are to determine when these species occur in Washington potato fields, the composition of the species in those fields, and the development of the larvae on potato foliage. We will present data from 2008 and 2009 field sampling and laboratory assays. Results of the laboratory assays of caterpillars fed potato foliage match field data to some extent. Spotted cutworm, *Xestia c-nigrum* (Linnaeus) and cabbage looper, *Trichoplusia ni* (Hübner) developed well on all potato varieties evaluated and constituted a majority of the larvae found in potato fields. Other species either were not found in the field or did not perform well on potato foliage. Using a variety of sampling techniques, efforts to trap adult moth species of concern were a success. From this data we see that June flights of spotted cutworm moths are important contributors to caterpillars feeding on potato crops in Washington. This research will provide growers with better information on what species are a problem, how to detect them, and how to time pesticide applications for maximum benefits.

8SPO
POTENTIAL FOR MANAGING THE CERAMBYCID BEETLE *PRIONUS CALIFORNICUS* IN HOP USING MASS TRAPPING AND MATING DISRUPTION

Elin Maki[1], Jocelyn G. Millar[2], Josh Rodstein[2], Lawrence M. Hanks[3] and J. D. Barbour[1]
[1]University of Idaho, Southwest Research and Extension Center, 29603 U of I Ln, Parma, ID
[2]University of California, Dept. of Entomology, 900 University Ave., Riverside, CA
[3]University of Illinois, Dept. of Entomology, 505 South Goodwin Avenue MC-118, Urbana, IL

The cerambycid beetle *Prionus californicus* Mots. is an economically important pest of many agricultural and ornamental plants and is broadly distributed in the western United States. In the Pacific Northwest, it is a serious pest of hop, *Humulus lupulus* L. (Urticales: Cannabaceae), a high value specialty crop that is an essential ingredient in the production of beer. Current recommendations for management of *P. californicus* involve expensive and labor intensive cultural methods and/or the use of the broad-spectrum organophosphate insecticide ethoprop. Female *P. californicus* are known to produce a sex pheromone that is highly attractive to males and this pheromone can now be synthetically produced. We will present data that evaluates the potential for synthetic pheromone based control strategies for *P. californicus* in hop. We conducted mark-recapture studies in commercial hop yards to determine the maximum distance over which males would respond to pheromone traps, and experiments to determine the effectiveness of mass trapping and mating disruption. Overall, 95% of the beetles recaptured were released from within 276 m downwind from a pheromone baited trap. Both mass trapping and mating disruption have strong potential as control strategies for *P. californicus* in hop.

9SPO
PHENOLOGY, SYMPTOMOLOGY AND CONTROL OF ERIOPHYID MITES IN LINDEN *(TILIA CORDATA)* IN ORNAMENTAL NURSERIES

Betsey Miller[1], Robin Rosetta[2], Vaughn Walton[1]
[1]Oregon State University, Department of Horticulture,
4017 Agriculture and Life Sciences Building, Corvallis, OR 97331
[2] Oregon State University, North Willamette Research and Extension Center,
15210 NE Miley Road, Aurora, Oregon 97002

In the nursery industry, eriophyid mites can cause significant crop losses due to damage to rapidly growing plant tissues during summer. Of particular interest is the loss of aesthetic value due to the loss of growth tips of both seedlings and large trees. Damage to leading shoots may necessitate training of new leaders which can significantly increase labor costs. In addition, high mite infestation can cause the shortening of internodes, leading to irregular branch spacing resulting in lower value products. Little is known about the seasonal phenology of these mites in nursery production systems in the Pacific Northwest. The size of eriophyid mites coupled with their cryptic behavior make monitoring difficult and reduces the ability to make informed management decisions. Often, damage occurs before the presence of mite infestations is detected. For this reason, nursery managers often do preventative sprays on a routine basis. It is believed that a better understanding of the seasonal phenology of mites may be useful to optimize the timing and targeting of control measures. Linden (*Tilia cordata*) is a popular and valuable nursery crop that is affected by eriophyid mites. This study uses Linden as a model species to observe the symptomology and seasonal phenology of eriophyid mites. In addition, data is presented from trials comparing timing of sulfur sprays for control of eriophyids in Linden.

10SPO
USING STABLE ISOTOPES TO DETERMINE THE IMPORTANCE OF SEEDS AND INVERTEBRATE PREY IN THE DIET OF A POLYPHAGOUS GROUND BEETLE

Laurel Moulton and Ed Peachey
Oregon State University, Department of Horticulture, 4017 ALS Bldg., Corvallis, OR

Pterostichus melanarius Illiger (Coleoptera: Carabidae) is a frequent and often dominant ground beetle species inhabiting agricultural fields in western Oregon. The beetle is highly polyphagous, and has been the subject of numerous dietary studies focusing on agricultural pests and weed seeds. Molecular analyses have focused on identifying and quantifying specific invertebrate prey within the guts of *P. melanarius*: mainly slugs, worms and aphids. The quantification of seed predation has relied on seed removal experiments in the field, and lab-based feeding trials. Using these methods, some researchers have suggested that *P. melanarius* and other carabid beetles are important invertebrate pest and post-dispersal seed predators in agricultural ecosystems, but thus far it is unclear what the relative importance or relative frequency of these food items are in their diets. Our objective is to test the efficacy of using stable isotopes and manual gut analyses to determine the relative occurrence of plant material to invertebrate material in the diet of *P. melanarius*, and whether it changes seasonally. This methodology may help predict and/or

quantify *P. melanarius'* impact on weed and invertebrate pest populations in agricultural lands. Preliminary data indicate that the isotopic signatures for the stomach contents of beetles collected in summer and early fall are similar: more depleted in $\delta^{13}C$ than would be expected from a primarily plant-based diet, but enriched in $\delta^{13}C$ compared to soil dwelling invertebrate prey items. These differences suggest a mixed diet that is more influenced by invertebrate prey than plant material.

11SPO
LABORATORY EVALUATION OF REGIONAL HARD AND SOFT SPRING WHEAT GENOTYPES FOR RESISTANCE TO HESSIAN FLY

Steven I. Odubiyi[1], Nilsa A. Bosque Pérez[1], Lana M. Unger[1], Kim G. Campbell[2]
[1]University of Idaho, Department of Plant, Soil, and Entomological Sciences,
P.O. Box 442339, Moscow, ID 83844-2339
[2]USDA-ARS Wheat Genetics, Quality, Physiology, and Disease Research Unit,
Washington State University, P.O. Box 646420, Pullman, WA, 99164-6420

The Hessian fly, *Mayetiola destructor* (Say) (Diptera: Cecidomyiidae), is a serious pest that causes economic damage to wheat, *Triticum aestivum* L. in most wheat-growing regions throughout the world. Its importance as a pest in the Pacific Northwest (PNW) has increased in the last 15 years. Host plant resistance is recognized as the most effective and reliable control measure. The objective of this study was to screen regional spring wheat breeding lines and cultivars for resistance to Hessian fly. Two separate laboratory assays were conducted to evaluate the response of twenty-seven hard and fifteen soft spring wheat genotypes to Hessian fly attack. The genotypes screened carry diverse genes for fly resistance, including the *H3* gene. Significant variation was observed in response to Hessian fly infestations among varieties tested in both laboratory screenings. Among the hard wheat genotypes, Clearwhite, Hank, Kelse, IDO702, IDO704, IDO705, WA008027, UC1601, UC1602 and A99454S-2 exhibited high levels of resistance against Hessian fly. Among the soft wheat genotypes, Nick and Louise were ranked as resistant and WA008039 and WA008090 as moderately resistant. Identification of these resistant genotypes will assist regional programs in their efforts to develop varieties with insect resistance. However, continued concerted efforts are still needed to develop resistant genotypes with multiple genes for resistance that will offer incompatible interactions with the virulent Hessian fly biotypes present in the PNW. Availability of such resistant genotypes will serve as a sound option for management of Hessian fly and ultimately increase wheat yield and reduce economic losses experienced by growers.

12SPO
POPULATION GENETICS OF *PACHYCONDYLA CHINENSIS*

Andrew Tebeau[1,2], Patricia Zungoli[1], and Matt Turnbull[1]
[1]Department of Entomology, Soils and Plant Sciences, Clemson University, Clemson, SC
[2]Department of Biology, Utah State University, Logan, UT

Populations of the Asian needle ant, *Pachycondyla chinensis* (Emery), have increased considerably in the last 80 years since its introduction into southeastern U.S., raising ecological and medical concerns in the scientific community. Due to the limited knowledge of the species life history we sought to characterize the population dynamics of 21 invasive colonies residing in six locations in South Carolina using microsatellite markers. The objectives of this study were to monitor estimated parameters of inbreeding, bottleneck, population structure, reproductive migrants, caste relatedness, and inter- and intra-colony relatedness to explore the possibility of unicoloniality while elucidating means in which this pest species is so successful. We found that these populations of Asian needle ants were not in Hardy-Weinberg equilibrium due to heterozygote deficiency. This was a result of high inbreeding coefficients caused by with-in nest mating. Two of the locations studied showed signs of a bottleneck but this was not detected globally. The population structure was that eight effective populations were detected in the six locations and at two locations the samples were collected from two separate populations. At one of these sampling locations, nests were intermixed between two populations while the other was more spatially divided. Estimations of reproductive migration between populations were low. Relatedness measurements between castes were low and suggested that queen contributions to offspring are not equal. Finally, relatedness and genetic fixation indices between and within colonies revealed that with-in a location, nests were not genetically different from neighboring nests, but that at a global scale, unicoloniality was not present.

13SPO
TO BEE OR NOT TO BE? IN ALFALFA PRODUCED FOR SEED, THERE IS NO QUESTION: POLLINATORS MUST BE PROTECTED

Amber Vinchesi[1], Douglas Walsh[1], Timothy Waters[2], Sally O'Neal[1], and Holly Ferguson[1]
[1]Washington State University, Environmental and Agricultural Entomology Laboratory, 24106 N. Bunn Road, Prosser, WA
[2]Washington State University, Franklin County Extension, 1016 N. 4th Ave, Pasco, WA

Maintaining populations of pollinating alkali bees, *Nomia melanderi* and/or alfalfa leafcutting bees, *Megachile rotundata*, is crucial for alfalfa seed production. It is a delicate balance for growers who must control pest Lygus bugs, *Lygus Hesperus*, while trying to preserve pollinators. Two key components of IPM in alfalfa seed are managing pesticide resistance and protecting pollinators. We have designed an experimental protocol to test bee pesticide safety. Subsequently, a series of insecticides and miticides have been screened for their toxicity to leafcutting and alkali bees. Treatments used for 2007 results included bifenazate (Acramite), naled (Dibrom), thiamethoxam (Actara), fenpyroximate (Fujimite), abamectin (Agrimek) with oil, HGW 86 10% SC, acetamiprid (Assail), spiromesifen (Oberon), flonicamid (Beleaf), imidacloprid (Provado), thiacloprid (Calypso), novaluron (Rimon), bifenthrin (Capture),

etoxazole (Zeal), and propargite (Comite). Exposure of bees to 1-hour residues has documented that all the pesticide treatments listed above except bifenthrin caused less than 25% mortality to bees. Experience has demonstrated that pesticides that cause less than 25% mortality with field-aged, 1-hour residues can be applied during evening or night with little hazard to bees. We continued the bee safety trials in 2009 with added treatments of dimethoate, metaflumizone (Alverde), spirotetramat (Movento), endosulfan, and a high (5oz per acre)/low (3.5oz per acre) dose of chlorantraniliprole (Coragen SC). Data from the 2009 trials was inconclusive due to significant mortality in the control populations. The safety trials will be continued summer 2010.

14SPO
VALIDATION OF METHYL SALICYLATE AS A MEANS TO IMPROVE CONSERVATION BIOLOGICAL CONTROL IN OREGON HOP YARDS

Joanna L. Woods[1], David G. James[2], Jana C. Lee[3], David H. Gent[4]
[1] Oregon State University, Department of Crop and Soil Science,
109 Crop Science Building, Corvallis OR 97331-300.
[2] Washington State University, Department of Entomology, Irrigated Agriculture Research and Extension Center, 24106 North Bunn Road, Prosser Washington 99350
[3] U.S. Department of Agriculture-Agricultural Research Service, Horticultural Crops Research Laboratory, 3420 NW Orchard Avenue, Corvallis OR 97330.
[4] U.S. Department of Agriculture-Agricultural Research Service,
Forage Seed and Cereal Research Unit, Oregon State University,
Department of Botany and Plant Pathology, 3450 SW Campus Way, Corvallis OR 97331

The use of synthetic herbivore-induced plant volatiles (HIPV) to attract natural enemies has received interest as a tool to enhance conservation biological control (CBC). Methyl salicylate (MeSA) is a HIPV that is attractive to several key predators of twospotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), and hop aphid, *Phorodon humuli* (Schrank) (Homoptera: Aphididae). Previous field deployment of MeSA in hop yards has been conducted in semi-arid production regions in Washington. In contrast, hop production regions in western Oregon have a maritime-type climate, which results in differing severity of these pests. A two-year study was conducted to validate the use of MeSA in Oregon hop yards. Slow-release MeSA dispensers were deployed in a 0.5 hec plot and compared to a paired non-treated plot on each of three farms in 2008 and 2009. In both years, there was a trend for reduced (40 to 91%) mean seasonal numbers of *T. urticae* in five of the six MeSA-baited yards. *Stethorus* spp., key spider mite predators, tended to be more numerous in MeSA-baited plots compared to control plots on a given farm. However, mean seasonal densities of hop aphid and other natural enemies were similar between MeSA-treated and control plots. Variability among farms suggests that the use of MeSA to enhance CBC of spider mites in commercial hop yards in Oregon may be influenced by site-specific factors related to the agroecology of individual farms. The current study also suggests that CBC of hop aphid with MeSA in this environment may be unsatisfactory.

15SPO
IDENTIFICATION OF LYGUS BUG SPECIES BY DNA BARCODING

Changqing Zhou[1], James D. Barbour[2], Frank G. Zalom[3],
Douglas B. Walsh[1,4], Laura Corley Lavine[1]
[1]Washington State University, Department of Entomology, PO Box 646382, Pullman WA
[2]University of Idaho, Parma Research & Extension Center, Parma, ID
[3]University of California, Davis, Department of Entomology, Davis, CA
[4]Washington State University, Department of Entomology and
Irrigated Agricultural Research & Extension Center, Prosser WA

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 and population genetic analyses to identify the specific species of Lygus in California, and alfalfa/ alfalfa produced for seed in Washington, and Idaho. Here we report our preliminary investigation of the relationships of Lygus bugs from California, Washington, and Idaho. We have sequenced approximately 500 bp of the mitochondrial cytochrome oxidase 1 gene from Lygus from each of these locations. This has provided evidence of haplotype differentiation and phylogenetic relationships of the bugs in this study. 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.

STUDENT COMPETITION POSTERS: PhD

16SPO
PRIMARY SEXUAL CHARACTERS AS USEFUL FEATURES TO DISTINGUISH GENERA OF AGENIELLINI (HYMENOPTERA, POMPILIDAE)

Cecilia Waichert[1], Carol von Dohlen[1], James P. Pitts[1]
[1]Utah State University, Department of Biology, 5305 Old Main Hill, Logan, UT

Ageniellini is the most morphological and biologically specialized group within Pepsinae. A diversity of reproductive behaviors occurs within the tribe, including communal nesting and parasocial behavior. Parasociality is possibly the first step towards sociality in insects and its study is crucial in understanding the evolution of eusociality. Phylogenetic and evolutionary studies of Ageniellini are thwarted, however, by their very similar morphology and often incorrect identifications. The males of *Ageniella*, *Auplopus, Phanochilus* and *Priocnemella* are the most difficult to identify. Herein, we attempt to determine for the first time how to distinguish the males of the Ageniellini genera using primary sexual characters, focusing on the most difficult genera. Although more taxa need study, our results reveal genitalic differences between the four genera. The main useful genitalic characters are differences in the length and shape of paramere, the distribution of setae on ventral surface of genitalia, and the shape of the cuspis. Species of *Ageniella* and *Auplopus* are the most variable in the tribe for both external and sexual features, as a consequence, morphological patterns were more difficult to define in those genera.

17SPO
EXPANDING THEORY IN PUSH-PULL MANIPULATIONS OF PESTIFEROUS INSECTS

Summer Lindzey[1], Sanford Eigenbrode[1], A. Nicholas Birch [2], William Snyder[3], Joyce Parker[3].
[1] University of Idaho, PSES Division of Entomology, Moscow, ID
[2] Scottish Crop Research Institute, Dundee, Scotland
[3] Washington State University, Dept of Entomology, Pullman, WA

Recently an approach known as “push-pull” has emerged in integrated pest management that seeks to reduce pest pressure by diverting a pest insect behaviorally from the target resource (which constitutes the “push”) while simultaneously directing it to another less-valued resource or trap crop (which constitutes the “pull”). Perhaps because of its apparent simplicity, the idea of push-pull has remained a largely general principle that lacks a well-developed body of theory. In this short review we provide a framework for expanding a theory of push-pull by analyzing it along the spatial and temporal scale of the host selection behavior it attempts to manipulate. We find an extreme bias towards the manipulation of long-range olfactory cues in published efforts to date, and a relative dearth of attempts to use shorter-range host selection cues, which may nonetheless be amenable to manipulation and intervention. We argue that a more systematic consideration of the range of mechanisms at work in insect host selection is necessary to derive a theoretical understanding of how and why push-pull manipulations can be effective.

18SPO

DETERMINING THE IMPACT OF SIX VINEYARD PESTICIDES ON THE PREDATORY MITE *TYPHLODROMUS PYRI*

Angela N. Gadino[1], Vaughn M. Walton[1], Amy J. Dreves[2]
[1]Department of Horticulture, Oregon State University, Corvallis, OR, 97331-7304
[2]Crop and Soil Science Department, Oregon State University, Corvallis OR, 97331-7304

Intensive management programs in Pacific vineyards are believed to contribute to pest outbreaks of the rust mite Calepitrimerus vitis (Nalepa). Laboratory bioassays were conducted to assess the effects of six vineyard pesticides on Typhlodromus pyri Scheuten, a key predator mite of C. vitis. Pesticides tested were micronized sulfur, whey powder (milk bi-product), manganese ethylene bisdithiocarbamate (mancozeb), boscalid (+ pyraclostrobin), myclobutanil and paraffinic oil at three different rates. Fungicide dilutions were directly sprayed onto adult female and juvenile (0-3 d) T. pyri and each treatment assessed to determine effects on direct mortality and fecundity.

Results indicate that five of the six fungicides tested can be classified as non-toxic to T. pyri as mortality levels were less than 50% for all rates 7-d after treatment. Paraffinic oil resulted in direct mortality greater than 50%, and displayed significantly higher differences from the untreated control. Sub-lethal effects were more pronounced than pesticide toxicity in these bioassays. Significant decreases were detected in the sulfur and mancozeb treatments compared to the untreated control. The percent fecundity reduction relative to the untreated control was highest in the sulfur (28%, 51.2%), myclobutanil (24.7%, 45.7%) and mancozeb (21.8%, 83.2%, 70%) treatments. Boscalid and whey displayed the least effect on fecundity across all bioassays. Fecundity comparisons across fungicides of similar rates, did show treatment differences at the 2x rate ($P \leq 0.001$) and 4x rate ($P \leq 0.05$). These results can be utilized as guidelines in vineyard IPM practices to enhance predator mite populations for biological control.

19SPO
RESPONSE OF BEE POLLINATORS TO WILDFIRE IN SAGEBRUSH STEPPE

Byron Love, Jim Cane
Bee Biology & Systematics Lab, Utah State University, 5310 Old Main Hill, Logan, UT, 84322

Great Basin rangelands have been severely degraded by human disturbances including excessive livestock grazing, the introduction of exotic and invasive grasses, and changing weather patterns. As a result, fire frequencies and intensities have increased dramatically during the past decades, perpetuating the downward ecological spiral of destructive fire and weeds. As part of a landscape-level approach to post-fire rehabilitation, land managers have been working to include native forbs in reseeding mixtures to increase habitat diversity and resist the spread of noxious weeds. Successful establishment of native forbs requires the presence of bee communities in post-fire habitats to provide pollination services. Understanding the response of bees to wildfire is therefore an important part of Great Basin rehabilitation efforts.

This study investigates the bee guilds sampled from a 15-year chronosequence of past large wildfire sites across sage-steppe habitats in the Great Basin. Paired plots were established far into the burn (>100 meters) and outside the burn to compare the following habitat characteristics: bee density in patches of target flowering hosts (primarily *Balsamorhiza* species); the richness and similarity of bee communities; and the diversity, and density, of forbs and shrubs. Preliminary results indicate that any and all life stages of most ground-nesting wild bees will escape injury from wildfire. Furthermore, in relatively mild burns of intact sage-steppe plant communities, entire bee communities exhibit excellent prospects for survival. However, where forbs do not bloom in the year following fire (especially in previously depauperate communities or hotter fires), surviving bee communities will need supplemental forage that blooms reliably the year after seeding.

20SPO
HISTORICAL BIOGEOGRAPHY OF APORINI (HYMENOPTERA: POMPILIDAE)

Juanita Rodriguez[1], Carol von Dohlen[1] and James P. Pitts[1]
[1]Utah State University, Department of Biology, 5305 Old Main Hill, Logan, UT

Members of the spider wasp tribe, Aporini (Hymenoptera: Pompilidae), are distributed primarily in the Americas, with only *Aporus* extending into Europe and Southern Asia. We conducted a historical biogeographic study to infer the age of the tribe, its ancestral area and the possible dispersal and vicariant events that led to its present diversity and distribution. Four nuclear genes (28S rRNA, wingless, long-wavelength rhodopsin, and elongation factor-1α) were sequenced and a total-evidence phylogeny was inferred using Bayesian methods. Fossil data were used to determine nodal divergence times using Beast v1.5.2. Our analysis produced a phylogeny with most nodes highly supported. The estimated date for the ancestor of Aporini was 20 Ma; *Aporus* diverged ~20Ma, *Euplaniceps* ~7 Ma and *Psorthaspis* ~11 Ma. Aporini probably originated in North America and members of *Aporus* later migrated to Asia through the Bering Land Bridge (~20 Ma). The presence of the group in Central and South America could be explained by gradual dispersal through the Isthmus of Panama. *Psorthaspis* probably originated in the Nearctic region before the formation of the Isthmus of Panama approximately 3 Ma, and migrated south relatively recently into northern and eastern Colombia. *Euplaniceps* also originated recently, but most likely in South America. Its current distribution, however, may be the result of long-distance dispersal or extinction in areas north of Brazil.

21SPO
EFFECTS OF TEMPERATURE ON DEVELOPMENT AND BEHAVIOR OF *EPEORUS ALBERTAE* (EPHEMEROPTERA: HEPTAGENIIDAE) NYMPHS

Melissa A. Scherr[1], David E. Wooster[2], Sujaya Rao[1]
[1]Oregon State University Department of Crop and Soil Sciences, ALS 3017, Corvallis OR
[2]Oregon State University, Hermiston Ag Res and Extension Center, PO Box 105, Hermiston OR

Temperature in river systems can be affected by anthropogenic disturbances. Temperature may potentially affect life histories of macroinvertebrates, altering behavior and biological functions. Temperature preferences and tolerance ranges for key taxa are therefore critical for understanding the impact of human-induced changes to water temperatures on river ecosystems. The objective of this study was to examine the effect of water temperature on the development and behavior of *Epeorus albertae* (McDunnough) nymphs. The nymphs were collected from the Umatilla River in eastern Oregon, and exposed to the following temperatures: 18, 22 and 28˚ C. Nymphs held at 28˚C exhibited increased growth rates compared to individuals held at 18 and 22˚C. However, at high temperatures the accumulation of nymphal tissues was not consistent with nymphs held in lower temperatures; ratios of head capsule width to total body length were significantly lower in individuals at 28º C compared to those held at the lower temperatures. To examine the effect of water temperature on behavior, active drift of mayflies was examined in experimental chambers held at 12, 18, 22 and 28˚C. The number of drifting insects observed was significantly higher at 28º C compared to 22, 18 and 12˚C. These results indicate that temperature is a factor influencing growth, development and behavior of *E. albertae,* and is likely to lead to limitations in habitat use of this mayfly..

22SPO
PREDATOR-PREY INTERACTIONS AND BIOLOGICAL CONTROL OF *LYGUS* SPP. (HEMIPTERA: MIRIDAE) IN ALFALFA SEED

Tiecoura Traore and James D. Barbour
Southwest Idaho Research Extension Center, Parma, Canyon Co.
Department of Plant, Soil, and Entomological Sciences, University of Idaho

Lygus bugs (Hemiptera: Miridae) are the most important insect pests in alfalfa seed production in the U.S. and are managed primarily with organophosphate, carbamate and pyrethroid insecticides. Effective biological control could help reduce negative impacts of lygus bug management on pollinators of alfalfa, and lygus bug natural enemies, and delay or prevent the development of insecticide resistance. Two major predators of lygus bugs in alfalfa seed are bigeyed bugs (Geocoris spp.) and damsel bugs (Nabis spp.). There is little information concerning the influence of alternative prey on lygus bug biological control provided by these generalist predators. The goals of this study were to conduct field experiments determining the impact of bigeyed bugs and damsel bugs alone and in combination on lygus bug (Lygus hesperus (Knight)) populations in the presence and absence of alternative prey (pea aphid, Acyrthosiphon pisum). Our results to date have shown that higher lygus bug survival is associated with a combination of high aphid numbers and no predators, while the lowest lygus bug survival was associated with no or low aphids levels with predators in combination or damsel bugs alone.

23SPO
A VAMPIRE TALE OF TACHINID ENDOPARASITIC COMPETITION

Nik G. Wiman[1], Vincent P. Jones[1], and Eric Curry[2]
[1]Washington State University, Tree Fruit Research and Extension Center, 1100 N. Western Ave., Wenatchee, WA
[2]USDA, ARS, Tree Fruit Research Laboratory, 1104 N. Western Ave., Wenatchee, WA

Two species of Tachinidae, *Nemorilla pyste* (Walker) and *Nilea erecta* (Coquillett), have been identified as important parasitoids of obliquebanded and *Pandemis* leafrollers (Lepidoptera: Tortricidae) in Pacific Northwest tree fruit. Overlapping host use (both species utilize only the 4^{th}-6^{th} instar of their leafroller hosts) and size of the flies relative to the host puts the maggots of these species into direct competition for host resources. *Nemorilla pyste* is gregarious, while *N. erecta* is solitary, and *N. erecta* typically prevails in interspecific competitive interactions. Mechanisms of direct endoparasitic competition in solitary Hymenoptera include hypermetamorphic adaptations such as fighting mandibles that are used to kill competitors in the host. Here we discuss investigations into the mechanisms of inter- and intraspecific competition in *N. pyste* and *N. erecta*; specifically we were looking for evidence of fighting in the solitary species *N. erecta*. We found that *N. erecta* does indeed attack competitors, whether conspecific or heterospecific. It does so by piercing competitors with a pair of dagger-like mouthparts that leave a clear wound impression in the moribund victim. We also found that this behavior is accompanied by a morphological adaptation in *N. erecta.* The fighting takes place in the 3^{rd} instar, and in this stage the dagger-like mouthparts are proportionally longer and protrude further from the head than in the gregarious species *N. pyste*. This research predicts that the first *N. erecta* maggot to emerge to the 3^{rd} instar will prevail in both inter- and intraspecific contests.

GENERAL POSTER SESSION

24PO
EFFECTS OF NEWER INSECTICIDES ON THE NATURAL ENEMY *DERAEOCORIS BREVIS* (UHLER) (HEMIPTERA: MIRIDAE)

Kaushalya G. Amarasekare, Peter W. Shearer and Amanda A. Borel

Oregon State University, Mid-Columbia Agricultural Research and Extension Center, Hood River, OR

Abstract: This study focused on lethal and sublethal effects of cyazypyr, rynaxypyr, spinetoram, novaluron, and lambda-cyhalothrin on the natural enemy *Deraeocoris brevis* (Uhler) (Hemiptera: Miridae) in the laboratory using second-instars and adults (males and females). Each insecticide was tested using concentrations that were equivalent to the high label rate (1x) and $1/10^{th}$ of that amount (0.1x) dissolved in 100 gallons of water. Lambda-cyhalothrin appeared to be acutely toxic to both nymphs and adults at both rates, while both rates of novaluron proved to be acutely toxic to nymphs. Cyazypyr, rynaxypyr and novaluron caused less toxicity to adults while rynaxypyr and spinetoram were less toxic to nymphs. Fecundity and fertility of adult females were affected by the high rate of novaluron and spinetoram. The high rate of spinetoram negatively affected the survival of nymphs. Spinetoram treated males had lower longevity. Cyazypyr caused some mortality to nymphs and affected their survival.

25PO
IDENTIFYING MOLECULAR MARKERS ASSOCIATED WITH HESSIAN FLY RESISTANCE IN THE SPRING WHEAT CULTIVAR 'LOUISE'

Arron H. Carter[1], Nilsa A. Bosque-Pérez[2], Lana M. Unger[2], Susan E. Cambron[3], Herbert W. Ohm[4], Kim K. Kidwell[1]

[1]Department of Crop and Soil Science, P.O. Box 646420, Washington State University, Pullman, WA, 99164-6420
[2]Department of Plant, Soil and Entomological Sciences, P.O. Box 442339, University of Idaho, Moscow, ID 83844-2339
[3]USDA-ARS, Crop Production and Pest Control Research Unit, West Lafayette, IN, 47907-2089
[4]Department of Agronomy, Purdue University, West Lafayette, IN 47907-2054

The Hessian fly, *Mayetiola destructor* (Say) is an important pest of spring wheat (*Triticum aestivum* L.) in the Pacific Northwest (PNW). The most effective control method is the use of resistant cultivars, and such cultivars are increasingly being used to control Hessian fly in the PNW. However, there is potential for emergence of biotypes capable of attacking resistant cultivars. Utilization of multiple genes for resistance is important in an overall pest management strategy. Marker-assisted selection can enhance resistance-breeding efforts. The objective of this study was to identify the chromosomal location and molecular markers associated with Hessian fly resistance in the spring wheat cultivar 'Louise'. One hundred eighty-eight $F_{5:6}$

recombinant inbred lines (RIL) from a Louise (resistant) by 'Penawawa' (susceptible) cross were evaluated for resistance to Hessian fly biotypes C, E, F and GP. Eight to fifteen plants per RIL were scored for resistance, and data were converted to reflect the percentage of susceptible plants within each line. Louise and Penawawa had average susceptibility values of 9% and 100%, respectively, whereas individuals within the RIL population ranged from 0 to 100% susceptible. Distribution of susceptibility values for the RIL population was bimodal, and skewed toward highly susceptible. A genetic linkage map consisting of 301 DNA markers was used for quantitative trait loci (QTL) analysis. One QTL, identified as *QHf.wak.1A*, was significantly associated with Hessian fly resistance at LOD scores ranging from 37.8 to 67.4, which accounted for 71 to 81% of the phenotypic variation. *QHf.wak.1A* was localized to a 20.1 cM region on wheat chromosome 1AS, flanked by the markers *Xpsp2999* and *Xcfd15*. Simple sequence repeat (SSR) markers associated with *QHf.wak.1A* are currently being used in marker-based forward breeding strategies to improve the durability of resistance in wheat cultivars.

26PO
WSU-DAS – THE ONLINE PEST MANAGEMENT SUPPORT SYSTEM FOR TREE FRUITS IN WASHINGTON

Ute Chambers, Brad Petit, and Vincent P. Jones

Washington State University, Tree Fruit Research and Extension Center, 1100 N Western Ave, Wenatchee, WA

The WSU-Decision Aid System (DAS, das.wsu.edu) is an online Integrated Pest Management (IPM) decision support system for Washington State tree fruit growers and pest managers. It provides easy-to-use pest management programs and helps to optimize management decisions for certain insects and diseases. DAS collects daily weather data from the WSU AgWeatherNet along with forecast data from the National Weather Service (NOAA) to predict insect and disease phenology information. Pest conditions are projected 1 to 10 days into the future giving growers and pest managers time to plan and implement management tactics. Current and projected pest conditions are linked to organic and conventional management and pesticide recommendations, summarized in an integrated pesticide database (WSU Spray Guide). DAS currently provides model output for 10 insect, 3 disease, and 1 horticultural model. The Historic Weather Data Center allows users to view and compare pest conditions using stored weather data. DAS also supports user-entered weather data. The DAS Help Center now contains an on-line user manual and short narrated video tutorials that explain step-by-step the various features of DAS. Constant efforts are being made to expand the DAS program. For example, a stable, fast, and reliable iPhone version of DAS, available in 2010, makes it easy to check models and recommendations on the go. In 2011, DAS will be available in Spanish for the growing Hispanic tree fruit grower community. Users are required to register (at no cost). A user survey in 2008 showed that users estimated the value of DAS at > $16M/year and used it on the majority of Washington tree fruit acreage.

27PO
THE MICROBIAL INSECTICIDE *CHROMOBACTERIUM SUBTSUGAE*

L.J. Chanbusarakum, A. Murray, R. Asolkar, D. Wallner, H. Huang, E. Tan, R. Lam, T. Johnson, M.E. Koivunen and P.G. Marrone

Marrone Bio Innovations, Inc., Davis, California; lchan@marronebio.com

Marrone Bio Innovations has licensed a technology based on a novel species of *Chromobacterium* from USDA and is developing it into a microbial bioinsecticide. The development work includes media optimization to maximize the yield of secondary metabolites responsible for insecticidal activity as well as formulation development for increased efficacy and storage stability. Current formulations showed activity against a wide variety of insect species in laboratory and greenhouse bioassays. Field trials with formulated material also show notable control against many insects. Studies are underway to examine activity against a larger spectrum of insects.

28PO
WESTERN INTEGRATED PEST MANAGEMENT CENTER

Diane Clarke, Rick Melnicoe, Linda Herbst

Western IPM Center, University of California
Davis, CA

The Western IPM Center (WIPMC) fosters the adoption of integrated pest management (IPM), a science-based decision-making process that identifies and reduces risks from pests and pest management strategies. We cultivate and maintain a pest management information network in the West to increase the economic benefits of adopting IPM practices and reduce the environmental and human health risks associated with managing pests. We facilitate partnerships across states, disciplines, and purposes in order to increase coordination of IPM research, education, and extension efforts and enhance responsiveness to critical pest management challenges. We listen to our stakeholders in order to identify problems and set priorities for IPM research and extension. Funding is available for Work Groups, Research, Extension, Outreach, and Publications. Detailed on-the-ground regional information on pest management practices and pesticide use is provided to federal regulators. Since 2004, WIPMC-funded projects have leveraged more than $11 million to support IPM research and implementation, representing a $2 return for each $1 awarded.

29PO
IMPROVED GREENHOUSE ASSAYS TO ASSESS *LYGUS HESPERUS* INJURY TO COTTON FRUIT

W. Rodney Cooper and Dale W. Spurgeon

USDA-ARS 17053 North Shafter Avenue, Shafter, CA

Cotton plants grown in greenhouse pots tend to have long internodes and reduced canopy structure compared with plants grown in the field. These differences in plant growth habit reflect differences in available resources that may influence plant response to stresses such as insect feeding, leading to conclusions that are not widely applicable. Our objective was to evaluate the influence of soil volume (and thus resources) on plant response to feeding by *L. hesperus*. We compared the plant growth and response to lygus feeding of cotton plants grown in 1-gal pots to that of plants grown in 180-gal planters. Plants were confined in cages with 1 or 3 lygus adults for 48-h. Lygus feeding damage was assessed by dissecting each square. Logistic regressions were used to analyze square damage and abscission on plants grown in pots with those grown in planters. In separate studies, damage caused by 0, 1, or 3 lygus per plant was compared after 48-h or 2-wk exposure times using 180-gal planters. Results from these preliminary studies will be used to improve methods to investigate lygus/cotton interactions and to screen germplasm for lygus resistance or tolerance under controlled greenhouse conditions.

30PO
GRAPEVINE GENETIC RESPONSE TO SULFUR AND PACIFIC SPIDER MITE (*TETRANYCHUS PACIFICUS*)

Michael J. Costello and Jeffrey C. Wong

Horticulture and Crop Science Dept., California Polytechnic State University, 1 Grand Avenue, San Luis Obispo, CA

Spider mites (family Tetranychidae) are significant grape arthropod pests in all of the major commercial US viticultural regions (California, Washington, New York). In California alone, approximately 248,000 acres of grapes were treated with miticides in 2008. Several studies have found a relationship between the application of sulfur, for grape powdery mildew (*Erisiphe necator*), and Pacific spider mite density. Our recent studies using microarray analysis indicate that sulfur dust triggers changes in the degree of up- or down-regulation of many genes, suggesting that some of these changes encourage developmental rate, longevity and/or reproduction of spider mites. Working with laboratory-treated 'Thompson Seedless,' we found changes of at least 1.5 times that of control vines in over 4,000 genes in sulfur-treated vines, and over 2,000 genes in vines fed upon by Pacific spider mite. We found 17 genes that were simultaneously down-regulated on sulfur-treated vines, but up-regulated with Pacific spider mite infestation. In addition, we found 14 genes that were up-regulated at least 15-fold with sulfur treatment.

31PO
RESPONSES OF *Myzus persicae* TO HEADSPACE VOLATILES OF *Nicotiana benthamiana* INFECTED WITH ARTIFICIAL MUTANTS OF *Potato leaf roll virus*

Sanford D. Eigenbrode, Hongjian Ding, Alex V. Karasev, Joseph Kuhl
Department of Plant, Soil and Entomological Sciences, P.O. Box 442339,
University of Idaho, Moscow, ID 83844-2339

The effect of virus infections on volatile organic compounds (VOC) released from plants, and on the responses of aphids to these compounds, were examined using the *Nicotiana benthamiana-Potato leafroll virus* (PLRV)-*Myzus persicae* pathosystem. Point mutations were induced within the PLRV viral gene, open reading frame 4 (ORF4). The mutations were designed to avoid disrupting gene ORF3/4 (which overlaps ORF4), thereby isolating the effects of ORF4 variation. Six of the resulting mutant strains were agroinoculated into *N. benthamiana*. Virus-free agro-inoculated and non-inoculated plants were employed as controls. PLRV titer was assessed with coat protein TAS-ELISA or RT-PCR; viral RNA from the plants was sequenced to validate successful transmission. Approximately 3 weeks after inoculation, VOC trapped from plant headspace were compared using gas chromatography/mass spectrometry. Total VOC production and the specific VOC blend differed significantly among PLRV mutants, one mutation eliciting particularly greater VOC release than the others, notably through greater release of nicotine. The emigration of apterous *M. persicae* in response to plants infected by the PLRV mutants was also studied. The bioassay employed measures aphid emigration rates while on screening placed above leaflets of the test plants, thus preventing aphids from assessing tactile and gustatory cues, and is conducted in darkness to eliminate visual cues. The mutation eliciting the greatest VOC production was more arrestant than other PLRV mutations or the wildtype. The result indicates that differences in the genetic sequence of gene ORF4 in PLRV can influence VOC release from infected potato plants and associated changes in aphid behavior.

32PO
CAN THE POSTHARVEST TREATMENT METABOLIC STRESS DISINFECTION AND DISINFESTATION (MSDD) CONTROL QUARANTINE PESTS IN FRESH COMMODITIES?

Peter Follett[1] and Lourdes Arévalo-Galarza[2]
[1]USDA-ARS, PO Box 4459, Hilo, Hawaii 96720
[2]Recursos Genéticos y Productividad-Fruticultura, Colegio de Postgraduados,
Carretera Mexico-Texcoco km 36.5, Montecillo, Mexico CP 56230

Metabolic Stress Disinfection and Disinfestation (MSDD) is a postharvest treatment that combines short periods of low pressure (vacuum) and high CO_2 with ethanol vapor to control pathogens and arthropod pests on commodities. The treatment was tested against four significant quarantine pests in Hawaii —Mediterranean fruit fly, oriental fruit fly and melon fly (all internal pests), and white peach scale (a surface pest). Application of vacuum alone or the combination of vacuum and ethanol vapor caused minimal mortality to naked fruit fly eggs, or fruit fly eggs or larvae in papaya fruit. Vacuum alone also had no effect on mortality of second stage white peach scale nymphs, but the combination of vacuum and ethanol vapor killed 98% of the nymphs tested. MSDD has potential as a disinfestation treatment for surface pests on fresh commodities, but not for internal pests such as fruit flies.

33PO
INTEGRATING CLASSICAL TAXONOMY AND INFORMATION TECHNOLOGIES IN BEE SYSTEMATICS: THE AMERICAN SPECIES OF *ANTHIDIUM*

Victor H. Gonzalez[1], Kimberly Huntzinger[1], Sam Droege[2] & Terry Griswold[1]

[1]USDA-ARS Bee Biology and Systematics Laboratory, Utah State University, Logan, UT
[2]Patuxent Wildlife Research Center U.S. Geological Survey, Beltsville, MD

Thanks to rapidly developing information and digital technologies new and powerful tools are now available to taxonomists. By integrating some of those technological tools to our on-going revision of the American species of wool carder bees (Megachilidae: *Anthidium* Fabricius), we show how such studies can be more meaningful to biologists and communicate effectively to non-specialists than classical approaches alone. About 80 of the nearly 200 species worldwide of *Anthidium* occur in the Americas, including two widespread adventive species from the Old World. In addition to the traditional taxonomic elements of keys, descriptions, illustrations and comparative statements, the following digital outputs are being produced: 1) specimen data captured and georeferenced in a relational database served through the Global Biodiversity Information Facility (GBIF); 2) fully illustrated species pages that include distribution maps, information on host plants and seasonality generated from the museum database; 3) an interactive digital identification guide that will assist conservation biologists, pollination providers and bee researchers to reliably identify these bees (http://www.discoverlife.org/).

34PO
ADAPTATIONS OF BEES AND WASPS FOR POLLEN COLLECTING FROM NOTOTRIBIC FLOWERS

Victor H. Gonzalez, Terry Griswold & Molly Rightmyer

USDA-ARS Bee Biology and Systematics Laboratory, Utah State University, Logan, UT

Nototribic pollination is exhibited by plants of the families Lamiaceae, Fabaceae and Scrophulariaceae. This type of pollination occurs in asymmetrical flowers in which the filaments and styles are located on the adaxial (top) side. When a bee or bird visits a flower, the pollen is deposited onto its head, bill, or back. Bees and some pollen wasps have independently developed a series of morphological and behavioral adaptations to collect pollen from nototribic flowers. Such morphological adaptations include distinctly flat areas of the face, rugose integument and stiff, proclinate, hooked or wavy hairs. Using reports from the literature and the examination of museum specimens, we provide a checklist of the bees and wasps with those modifications. The list consists of more than 70 species in 22 genera from five of the seven extant bee families. Most bees with specialized structures for pollen collecting from nototribic flowers belong to the long-tongued families Apidae and Megachilidae. Among wasps, specialization has occurred in only few species of two genera in the family Masarinae. We discuss the morphological and behavioral adaptations as well as the geographical and phylogenetic occurrence in bees and wasps.

35PO
SENSORY STUDIES ON THE EFFECTS OF MITE, APHID, AND POWDERY MILDEW INJURY ON THE FLAVOR COMPONENTS OF SINGLE-HOPPED PALE ALES

Dan Groenendale[1], Mark Nelson[2], Deborah Brooks[1], Wilson Peng[1], Sally O'Neal[1], James Barbour[3], and Doug Walsh[1]
[1]Washington State University, Environmental Agriculture and Entomology Laboratory, Prosser, WA, [2]Washington State University, Irrigated Agricultural Research and Extension Center, Prosser, WA, [3]University of Idaho Parma Research & Extension Center, Parma, ID

Hops, *Humulus lupulus,* are the key crop used for bittering, enhancing aroma, and flavoring fermented malted beverages worldwide. Hops were first used in beer as a flavoring and preservative in Asia over 10,000 years ago. The US is the largest producer of hops. Over 98% of US hop production representing 27% of world production is concentrated in the Pacific Northwest. Production of hops on 40,000 acres collectively among Idaho, Oregon and Washington was 95 million pounds in 2009. The 2009 PNW hop crop was valued at $336 million but its added value to the 40 billion liters of beer it enhanced is priceless. The three most damaging foliar pests of hops in the PNW are the two-spotted spider mite (TSSM), *Tetranychus urticae,* hop aphid, *Phorodon humuli,* and powdery mildew, *Podosphaera maculari.* We are developing integrated management practices (IPM) for controlling these pests for the PNW growing region. We will be conducting a pair-wise sensory analysis *t*-test among members of the PBESA of single-hop pale ales to determine if PBESA members have preference toward brews made with hops impacted by mites, aphids, or mildew versus brews made with undamaged hops.

36PO
EFFICACY OF SPIROTETRAMAT AGAINST APHIDS, MEALYBUGS, THRIPS AND WHITEFLIES ON ANTHURIUM AND FLORAL GINGER

Arnold H. Hara, Susan K. Cabral, Ruth Y. Niino-DuPonte and Kris L. Aoki
University of Hawaii at Manoa, Beaumont Agricultural Research Center,
875 Komohana Street, Hilo, HI 96720

Foliar and drench application of spirotetramat was applied against banana aphids, *Pentalonia nigronervosa* (Coquerel), citrus mealybug, *Planococcus citri* (Risso), long-tailed mealybug, *Pseudococcus longispinus* (Targioni-Tozzetti), anthurium thrips, *Chaetanaphothrips orchidii* (Moulton) , banana rust thrips, *Chaetanaphothrips signipennis* (Bagnall), anthurium whitefly, *Aleurotulus anthuricola* Nakahara, on anthurium, *Anthurium andraeanum* 'Marian Seefurth' and floral ginger, *Alpinia purpurata* (Vieill.) K. Schum. Drench application against the anthurium whitefly was the most effective ($P<0.05$) treatment providing whitefly control for over 17 weeks after treatment. At 8 weeks after treatment, there was a trend of less anthurium thrips damage on plants treated with spirotetramat as a drench and foliar application, but it was not significantly different ($P>0.05$) from untreated plants. Similarly, drench application of spirotetramat was the most effective ($P<0.05$) treatment against banana aphids, and citrus and longtailed mealybugs on floral ginger. These studies demonstrate that spirotetramat is more effective as a drench than as a foliar application against foliar aphids, mealybugs and whiteflies.

37PO
THE PREVALENCE OF CODLING MOTH IN ORNAMENTAL PEAR TREES AND THE IMPLICATION FOR HORTICULTURAL PEST AND DISEASE BOARDS.

Gwen-Alyn Hoheisel[1] and Tom Wilson[2]

[1]WSU Extension, 1121 Dudley Ave, Prosser, WA, ghoheisel@wsu.edu
[2]Franklin County Horticultural Pest and Disease Board, 1016 N 4th, Pasco, WA 99301

During 2007, the codling moth stings were found on the fruit of ornamental pears planted in Pasco, Washington. Previously, it was commonly believed that the fruit on ornamental pear was too small and too hard for codling moth to develop successfully. In 2008 and 2009, 445 and 352 bags, respectively, were placed around fruit on 4 different cultivars of ornamental pears to examine emergence rates and successful maturation. All 4 cultivars were susceptible to stings. Over two years 12-13% of the larvae successfully pupated to adults, while 8-27% emerged but remained larvae. The first adult emergence coincided with the second flight in codling moth, but development for many larvae was slow, sometimes taking an entire season to emerge. Based on total fruit counts on trees, the number of stings ranged from almost none to less than a quarter of the fruit infested. The density of stings seems to increase as the proximity to alternative hosts (pears, apples, crabapples, etc) increase.

Since the codling moth in ornamental pears are more prevalent near alternative host trees and having relatively low emergence rate, the Benton and Franklin County Horticultural Pest and Disease Boards will continue to focus their enforcement efforts on primary host trees such as backyard apple, crabapple, and pears. They will also work with the cities to prevent developers from planting ornamental pears along new housing developments.

38PO
A NOVEL AUTOMATED TRAP DESIGN IS DEVELOPED FROM INITIAL TESTS OF CODLING MOTH AND ORIENTAL FRUIT MOTH TRAPS

Brian Lehman[1], Larry Hull[1], Vince Jones[2], Johnny Parks[3], Katie Ellis[4]

[1]Pennsylvania State University, 290 University Drive, Biglerville, PA
[2]Washington State University, 1100 N Western Ave, Wenatchee, WA
[3]Purdue University, 465 Northwestern Ave, West Lafayette, IN
[4]Pennsylvania State University, 670 Old Harrisburg Rd, Gettysburg, PA

Insect monitoring can provide valuable information about orchard pest populations, allowing for better timing and/or reduced pesticide costs. However, traps must be checked often to track population dynamics and determine economically-damaging densities. Automated insect traps have the potential to reduce labor costs as well as increase accuracy and timeliness of insect counts. In 2009, an automated, electronic sex pheromone prototype trap was tested for efficacy in monitoring codling moth, *Cydia pomonella* (L.) and oriental fruit moth, *Grapholita molesta* (Busck). Due to the differential selectivity of various styles and colors of conventional orchard traps, initial studies were conducted on the effect of color and trap type on adult moth and non-

target insect captures. Trapping records from standard delta traps (orange, white, or clear) were compared to those from bucket style funnel traps (orange, white, or green). The capture rate from the bucket traps was lower than that from the delta traps in all but one trial. Orange bucket traps generally attracted more codling and oriental moths than the other bucket colors. Since delta traps were not suitable for housing the electronic components of the automated design, the orange bucket trap was selected for the electronic prototype. Fifteen prototypes—each with internal clock and infrared components for detection of insects passing through the funnel—were tested. Prototype capture rates were low, probably due to deterring ultrasonic waves emitted by the clock mechanism. False capture events were also recorded, possibly during extra flights up and down the trap tunnel as the insecticidal kill strip slowly took effect.

39PO
EVALUATING NOVALURON MORTALITY OF IMMATURE ALFALFA LEAFCUTTING BEES, *MEGACHILE ROTUNDATA*

Theresa L. Pitts-Singer[1], Erin W. Hodgson[2], and James D. Barbour[3]

[1]USDA-ARS Bee Biology and Systematics Laboratory, Utah State University, Logan, UT
[2]Department of Entomology, Iowa State University, Ames, IA
[3]Parma Research and Extension Center, Parma, ID

Anecdotal reports from users of ALCBs for pollination of alfalfa in Idaho, Utah, and Colorado have indicated exceptionally poor bee return from fields treated with novaluron (Rimon 0.83 EC, Chemtura USA Corporation) to control *Lygus* bugs. In particular, observers noticed a high incidence of dead eggs or early instars (i.e., pollen balls). Novaluron is an insect growth regulator that disrupts cuticle formation and prevents molting. It acts by contact or ingestion, and as with other insect growth regulators, targets immature life stages. Our objectives were to evaluate novaluron toxicity to immature ALCBs and possible mechanisms of novaluron exposure to protected eggs and larvae. This research was designed to be the "worst case scenario" for maximum exposure of novaluron to ALCBs and their progeny. Under any novaluron treatments, adult bees were not affected, but eggs failed to hatch. Also in field cages where novaluron was applied, nesting females amassed provisions with detectable levels of novaluron, ranging from 236-656 ppb. Three potential scenarios explain egg mortality in this experiment: 1) female bees ingest novaluron while cutting leaf pieces for cell linings and caps; 2) the females ingest novaluron while collecting pollen and nectar, and reguritate tainted provisions; 3) tainted leaf pieces touch the provisions, and the chemical leaches from leaf to provision to eggs and developing progeny; 4) nectar and pollen are tainted directed by the field application. Caution should be used when using this product to control *Lygus* on alfalfa while bees are nesting. More investigations are forthcoming.

40PO
BOMBUS HUNTII (HYMENOPTERA: APIDAE): A WESTERN NORTH AMERICAN BUMBLE BEE AS A POTENTIAL COMMERCIAL POLLINATOR

James P. Strange
USDA-ARS Pollinating Insect Research Unit, Utah State University, 255 BNR,
Logan, UT 84322-5310

There is presently no commercial bumble bee pollinator native to western North America available for widespread commercial use. Because of concerns over the ecological impacts of transporting pollinators out of their native ranges, there is a need to develop a viable western pollinator specifically for the greenhouse industry in the USA, Canada and Mexico. *Bombus huntii* Greene is native to all three countries and has shown potential for commercial rearing. The present study outlines techniques for rearing the species in a laboratory setting, harvesting a second generation from lab-reared colonies, captive mating, overwintering and pollination potential in a greenhouse setting. Three nest initiation methods were tested and colony growth and size parameters were measured. Queens and males were collected at the end of the first generation and mated in a controlled environment and queens were then placed in an artificial wintering environment. The F1 generation queens were then removed from winter conditions and induced to nest for a second generation. Finally, *B. huntii* were used for pollination of both greenhouse grown bell peppers and tomatoes. These results suggest that *B. huntii* is a good candidate for further development as commercial pollinator.

41PO
INSECTICIDE CONTROL OF VINE MEALYBUG IN CALIFORNIA VINEYARDS

Lucia G. Varela and Rhonda J. Smith
University of California Cooperative Extension, 133 Aviation Blvd., Suite 109, Santa Rosa, CA

High populations of vine mealybug, *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae), pose potential economic loss in winegrapes. Post harvest transport of vine mealybug infested clusters and subsequent winery pomace disposal provide opportunity for spread of vine mealybug to previously non-infested areas. Population suppression in clusters at harvest is a primary goal of a control program both to reduce crop damage and loss, and to decrease likelihood of geographic spread. Twelve treatments were replicated four times in a randomized complete block design. Acetamiprid, buprofezin, clothianidin, dinotefuran, imidacloprid, spirotetramat and thiamethoxam were tested alone or in combination. Acetamiprid, buprofezin, dinotefuran, clothianidin and spirotetramat were applied to the foliage. Dinotefuran, imidacloprid and thiamethoxam were applied to the soil via chemigation.

Of all products and combinations tested buprofezin and spirotetramat provided the most effective vine mealybug control with two and one application per season respectively. Thiamethoxam, when combined with spirotetramat did not provide more effective control than spirotetramat alone. No single neonicotinoid provided control similar to buprofezin or spirotetramat. Of the neonicotinoids tested, acetamiprid treated vines had the fewest vine mealybugs in clusters at harvest.

42PO
FIRST REPORT IN THE UNITED STATES OF EUROPEAN GRAPEVINE MOTH, *LOBESIA BOTRANA* (LEPIDOPTERA: TORTRICIDAE) IN NAPA VALLEY VINEYARDS

Lucia G. Varela

University of California Cooperative Extension and Statewide IPM Program,
133 Aviation Boulevard, Suite 109, Santa Rosa, CA

Lobesia botrana (Denis & Schiffermüller), European grapevine moth (EGVM), has recently been found for the first time in the United States in vineyards in Napa Valley, California. This moth belongs to the family Tortricidae, sub-family Olethreutinae. Unlike other tortricid moths that are grapevine pests, EGVM larvae do not roll or feed on leaves — they feed on flower parts and more importantly they feed inside the berries. Larvae feeding on the berries trigger infections caused by the fungus *Botrytis cinerea*. Botrytis bunch rot disease is the main cause of fruit loss. *L. botrana* is native to southern Italy; it was first described from Austria and is now found throughout Europe, North and West Africa, the Middle East, and eastern Russia. In 2008 it was reported in Chile. The preferred hosts are *Vitis* spp. and *Daphne gnidium*, a common shrub in Mediterranean Europe. Adult moths are approximately ¼ inch long, tan-cream colored mottled with gray-blue, brown and black blotches. Females lay single, elliptical, flat eggs almost exclusively on flower clusters and berries. It has two and three generations in northern and southern Europe, respectively, and may have a partial fourth generation in warmer regions of Spain, Greece, Jordan, and Egypt.

In mid-September 2009, the first report of the EGVM in North America was confirmed in Napa County, CA. Based on available data at the end of 2009, geographic distribution within California is considered limited to Napa County. Full delimiting will take place in the spring.

43PO
ODOR DISCRIMINATION IN TWO CONDITIONED SOLITARY BEES, *OSMIA LIGNARIA* AND *MEGACHILE ROTUNDATA* (HYMENOPTERA: MEGACHILIDAE)

Cory A. Vorel[1] and Theresa L. Pitts-Singer[2]

[1]Department of Biology, Utah State University, Logan, UT 84322
[2]USDA-ARS Bee Biology & Systematics Laboratory, Logan, UT 84341

For decades, scientists have been using conditioning experiments to explore the cognitive processes of honey bees, as well as the neurophysiological and molecular mechanisms underlying those processes. Few studies have utilized conditioning to further understand learning and cognition in solitary bees. In this study, two species of solitary megachilid bees, *Osmia lignaria* Cresson and *Megachile rotundata* Fabricius (Hymenoptera: Megachilidae) were conditioned to discriminate between particular floral odors during feeding bioassays in the laboratory. As expected, both species were able to learn and to discriminate between floral odors in the bioassays, although some differences between species and between sexes were noted.

44PO
IDENTIFICATION OF CODLING MOTH GENES BY DEGENERATE PCR

Steven Weaver[1], Stephen F. Garczynski[2], Laura Corley Lavine[1]
[1]Washington State University, Department of Entomology, PO Box 646382, Pullman WA
[2]USDA-ARS, Yakima Agricultural Research Laboratory, 5230 Konnowac Pass Rd, Wapato WA

The overall goal of this project is to identify and characterize targets in the codling moth that can potentially be used in the control of this insect pest. The main targets are proteins important in pathways that regulate critical physiological functions in the insect. Four physiological systems, endocrine (hormones), chemosensory (smell and taste), reproductive (egg formation and development), and digestive, are being examined in this study. In the past year, several gene transcripts encoding proteins involved in the above physiological pathways have been identified in the codling moth. Neuropeptides and peptide hormones regulate most every physiological system in animals. In humans, deficiencies in the endocrine system are the causes of many diseases, and receptors for neuropeptides and peptide hormones are targets of many drug discovery efforts. For the codling moth, and other insect pests, disruption of the endocrine system as a target for insect control has been successful, leading to the development of the juvenile hormone and ecdysone mimics currently used in orchards today. We describe several codling moth genes identified by degenerate PCR that may be useful as targets for future integrated pest management strategies of codling moth control.

45PO
THE POTENTIAL OF EXTENSIVE GREEN ROOFS TO PROVIDE URBAN ARTHROPOD HABITAT

Tammy Winfield [1] John Lambrinos[1]
Oregon State University, Horticulture Dept., 4017 ALS Bldg., Corvallis, OR 97331-7304

Extensive green roofs are rooftop plantings designed to ameliorate the ecological impact of buildings. Extensive green roofs provide quantified reductions in stormwater runoff, and are currently being promoted as a tool for stormwater management. Green roofs could also provide habitat for urban arthropods, but the magnitude of this potential service has not been quantified. In this study we compared the flying arthropod community supported by a typical green roof design, a bare roof, and an adjacent weedy meadow. We conducted the study at the Oak Creek Center for Urban Horticulture at Oregon State University. We used experimental roofs either planted with a common set of six native and non-native plant species or left bare. Sampling was conducted from June 2007-October 2008. In both 2007 and 2008 we sampled arthropods bi-weekly on the roofs and in an adjacent weedy meadow using sticky traps. In 2008 sampling was amended with the use of pan traps, and visual counts. Arthropod biomass was greater in the weedy meadow than in either of the roof treatments, but green roofs supported almost twice as much arthropod biomass than did bare roofs. Green roofs supported a slightly greater average richness of arthropod morph-types than bare roofs, but this difference was only significant during a few sampling periods. Some notably beneficial insects such as wasps, bees, and syrphid flies were significantly more abundant on green roofs than bare roofs. These results suggest that extensive green roofs can potentially provide important arthropod habitat in urban environments.

46PO
SPECIES COMPOSITION OF CUTWORM LARVAE (LEPIDOPTERA: NOCTUIDAE) IN SOUTH CENTRAL WASHINGTON VINEYARDS

Larry Wright[1], David James[1], Victor Reyna[1], Sandra Castle del Conte[1], Stacy Gingras[2], Peter Landolt[3], and Tora Brooks[1]

[1]Irrigated Agriculture Research and Extension Center, Washington State University, 24106 N. Bunn Road, Prosser, WA [2]Department of Biology, Yakima Community College, 500 West Main Street, Grandview, WA [3]USDA-ARS, 5230 Konnowac Pass Road, Wapato, WA

The major grape growing areas of Washington were surveyed during the springs of 2003-2007 to determine the cutworm species that were present as larvae in vineyards. We sampled vineyard floors during the daytime, vines at night because cutworms are active at night, and vines during the day. We collected a total of 1,003 larvae and reared 650 to adults for identification. Twenty-five species were found: 22 on the ground, eight on vines at night, and two on vines during the day. Almost 75% of the cutworms on vines at night were *Abagrotis orbis* (Grote) and 19% were *Agrotis vetusta* Walker. The spotted cutworm, *Xestia c-nigrum* (L.), and the redbacked cutworm, *Euxoa ochrogaster* (Guenée), were previously reported to be the major cutworm pests of grapes in Washington, but only four *X. c-nigrum* and no *E. ochrogaster* were collected. *Abagrotis orbis* larvae were collected on grapes at night from mid-March to late April. Adults emerged in the laboratory in mid-May and they were present during the summer. *Agrotis vetusta* larvae were collected on grapes from 1 to 30 April. This species had a long prepupal period during the summer. Mean adult emergence was in early August. Both species mated and laid eggs during the fall and overwintered as small larvae.

47PO
INSECTICIDE INDUCED RESURGENCE OF BROWN PLANTHOPPER, *NILAPARVATA LUGENS*, IN THE TEMPERATE RICE ECOSYSTEM

Yoohan Song[1], Hong-Hien Pham[2]

[1]Institute of Agriculture and Life Science, Gyeong-Sang National University, Jinju 660-701, KOREA, [2]Plant Protection Research Institute, Dongngac, Tuliem, Hanoi, VIETNAM

The brown planthopper (BPH), *Nilaparvata lugens*, is a great threat to rice production in Asian rice-growing areas. Resurgence of BPH caused by heavy pesticide applications is known as a common phenomenon in the tropical rice area; however, no obvious evidence of the BPH resurgence has been examined in the single cropping rice ecosystem in the temperate rice area such as in Korea. The resurgence of BPH in Korea after spraying insecticides revealed significant differences in the population dynamics of BPH in sprayed and unsprayed fields. The peak density of BPH in sprayed field occurred one week earlier and 20 times higher than in unsprayed field. The main factor that affected the resurgence of BPH seemed to be the death of spiders in the rice field caused by foliar spray. After the insecticide sprays, the ratio of the number of ambush spider and hunting spider groups to the number of BPH in sprayed field was always lower than in unsprayed field. Among the granular insecticides, carbofuran was the most toxic to Lycosid spiders, followed by carbosulfan and diazinon. Imidacloprid was shown to have lower toxicity on Lycosid spiders. The most toxic was the aerial spray insecticide, BPMC, which showed 100% Lycosid spider mortality 12 hours after application a dosage of 500ppm. In conclusion, insecticide inducing the BPH resurgence was obvious in temperate area of Korea.