Enhancing Biological Control in Western Orchards

A USDA-NIFA Specialty Crop Research Initiative Project

A collaborative project between Washington State University, University of California at Berkeley, Oregon State University, USDA-ARS, USDA-NIFA, and the apple, pear and walnut industries in California, Oregon, and Washington.

Project Directors

Washington State University:
- Vincent P. Jones (Project Director)
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- Peter W. Shearer
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Advisory Group

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Canada: Dr. Gary Judd (Agriculture and Agri-Food Canada, outside scientist)

Project Goals

• Improve the long-term sustainability of the apple, pear and walnut industries in the western US by enhancing biological control (BC) of pest insects and mites.

• Synthesize the information developed in this project along with existing information to provide the outreach tools needed to bring about change in grower practices.

Objectives

1. Evaluate the sublethal effects of newer pesticides on key natural enemies in laboratory and field assays in apple, pear, and walnut orchards.

2. Characterize natural enemy phenology, including timing of emergence from overwintering areas, entry into orchard, and development within the orchard.

3. Evaluate attractants as natural enemy monitoring tools and compare them to traditional methods.

4. Develop molecular and video methods to monitor predation of codling moth (CM).

5. Conduct economic analyses to determine long-term costs associated with IPM programs with and without various levels of biological control.

6. Survey clientele to identify optimal ways to present information that will lead to quicker adoption of new technologies; synthesize existing and new information to provide real-time support for pest control decisions by stakeholders.
Over, but not done

Our project officially ended on 31 August. However, the official end is not the end of the project and we have leveraged the SCRI funding well beyond the initial 1:1 match, with at least an additional $1.8 M in new grant funds to expand on the original objectives and also to bolster the outreach efforts.

For this progress report, we will provide a short overview of the accomplishments for each objective, as well as showing some of the exciting new research and extension directions that have been taken by some of our project directors. We also provide a comprehensive list of publications, presentations, leveraged grants, and the training opportunities that this SCRI grant has helped fund or that is an outcome of the leveraged funding. We think that our productivity has been extraordinary, with 92 presentations, 31 additional symposia presentations (with 9 more coming in 2014), 21 popular articles, 26 peer-reviewed articles in print or in press, and a special issue of the journal Biological Control that will have 14 additional peer-reviewed articles, a two-day short course presented at 3 locations over video conference, more than twelve 2-4 hour training courses on natural enemies and a state of the art web site that pulls all this together (enhancedbiocontrol.org).

We hope you enjoy the report and find our results and new directions to be a clear indication of our passion for both basic and applied research, the excellence of our team, and the importance of taking a broad and fresh approach to integrating biological control into normal orchard management programs.

For more information on this project and our accomplishments, please visit our web site (enhancedbiocontrol.org) and feel free to contact our project directors.

Pesticides Influence Biocontrol Success

I. Pesticide Effects
Mills, Beers, Shearer, Unruh

This objective has successfully characterized the potential disruptive effects of seven different pesticides used for management of codling moth and diseases on a set of natural enemies that contribute to the management of secondary pests in western apple, pear and walnut orchards. Detailed laboratory tests designed to integrate both acute and sublethal effects of pesticides on natural enemies led to the development of a simple visual chart summarizing the relative compatibility of each pesticide with natural enemies (top next page; enhancedbiocontrol.org/pe.html). Follow-up studies in apple, pear and walnut orchards were used to confirm the strongest disruptive effects seen in the laboratory tests on the ratio of natural enemies to secondary pests, which is a useful index of biological control activity in the field. This information has already been incorporated into the decision making of a number of leading pest managers throughout the region, and is being used in educational programs associated with the project. We anticipate this information will result in enhanced conservation of biological control agents in western orchards and reduce the need for pesticide applications against secondary pests in these crops.

Benefits to Science and the Agricultural Industries

The accomplishments from the project include significant advances in both science and industry application. From a science perspective, the project has generated the first larger scale application of life table statistics to the laboratory assessment of pesticide risk to natural enemies and provides a framework of standardized protocols for rigorously testing pesticide selectivity. Benefits to the tree crop industries have been twofold: First, growers and pest managers have become increasingly aware of the importance of the biological control services that natural enemies can provide if not disrupted by indiscriminate use of pesticides. Secondly, this awareness has encouraged them to question whether changes in pesticide registration in these crops could be responsible for the novel secondary pest complexes that have arisen in recent years. Consequently, this has led to a series of new industry-sponsored research projects in all three states that are geared toward enhancing the role of biological control in the management of secondary pests such as aphids, pear psylla, and spider mites.
Percentage change in the population size of treated populations compared to untreated controls after one generation, estimated from laboratory life table bioassays. Green cells show <25% reduction, yellow have 25-75% reduction, and red have >75% reduction

<table>
<thead>
<tr>
<th>NE tested</th>
<th>Altacor</th>
<th>Cyazypyr</th>
<th>Delegate</th>
<th>Rimon</th>
<th>Warrior</th>
<th>Kumulus</th>
<th>Kocide/ Manzate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woolly apple aphid parasitoid, <em>Aphelinus mali</em></td>
<td>-4.2</td>
<td>-56.8</td>
<td>-84.5</td>
<td>-26.9</td>
<td>-72.8</td>
<td>3.7</td>
<td>12.2</td>
</tr>
<tr>
<td>Walnut aphid parasitoid, <em>Trioxys pallidus</em></td>
<td>-58.7</td>
<td>-88.5</td>
<td>-83.2</td>
<td>-7.0</td>
<td>-90.7</td>
<td>-89.1</td>
<td>-23.5</td>
</tr>
<tr>
<td>Pear psylla predator, <em>Deraeocoris brevis</em></td>
<td>5.0</td>
<td>10.4</td>
<td>-76.8</td>
<td>-98.2</td>
<td>-99.2</td>
<td>-65.9</td>
<td>-31.8</td>
</tr>
<tr>
<td>Aphid predator, <em>Hippodamia convergens</em></td>
<td>-87.3</td>
<td>-84.1</td>
<td>-21.1</td>
<td>-86.5</td>
<td>-99.8</td>
<td>-4.4</td>
<td>-10.5</td>
</tr>
<tr>
<td>Mite predator, Western predatory mite <em>Galendromus occidentalis</em></td>
<td>-12.4</td>
<td>-36.1</td>
<td>-97.5</td>
<td>-73.9</td>
<td>-98.5</td>
<td>-90.7</td>
<td>-77.1</td>
</tr>
</tbody>
</table>

Knowing Phenology Improves Management Options

2. NE Phenology Models
Jones, Mills, Shearer, Horton, Unruh

Phenology models have been developed for two lacewings (*Chysopa nigricornis*, *Chrysoperla plorabunda*) and a syrphid fly (*Eupeodes fumipennis*), and we are working on at least two more. There is more data from apple orchards than all other crops, so we developed the models using a subset of the apple data, and then validated the model using the remainder of the apple data. The apple models were then tested in cherry, pear, and walnut orchards to check for significant departure. Our average error with the models for the lacewing *Chrysopa nigricornis* was similar in the two different areas of Washington tested, and California, but were roughly 40% higher in Oregon (HR, figure on right). We are not sure why the Oregon data had higher errors, but it is not related to differences in crops, since both cherry and pear orchards in Washington fit the apple data similarly to the apple validation data. We are currently evaluating the different spray programs to see if that explains the differential errors in Oregon.

Benefits to Science and the Agricultural Industries

The phenology models for natural enemies are merely extensions of the theory used to develop phenology models for pest insects. However, they are an advance in the sense that we found that the phenology in our systems could be predicted solely by temperature accumulations, and did not require information on the host or prey populations levels. We also found that a single model for each natural enemy had similar accuracy in all crops, except in situations where pesticide use was excessive.

The models provide the industries precise information on when different natural enemies occur. In particular, we found that the lacewing, *Chrysoperla plorabunda* and the syrphid flies (*Eupeodes fumipennis* and *Eupeodes volucris*) occur much earlier in the season than previously expected. Our data suggest that we need to re-consider the pesticides used, timing, and the particularly the delayed dormant sprays in all three crops. Ultimately, we expect that we can use our data from this and leveraged projects to generate at least five phenology models that are important to a range of our key pests in western orchards. These models will be be delivered through the WSU-Decision Aid System and provided to the researchers in Oregon and California for implementation in those states.

Mean absolute deviation error for the *C. nigricornis model*. Wen develop (red bar) is the Wenatchee apple data (2009) used to develop the model, all other data is completely independent and used to validate the model. YA - Yakima, HR-Hood River, Wen - Wenatchee.
Improved Monitoring Tools Make Biocontrol Visible

3. NE Monitoring Tools
Jones, Mills, Shearer, Horton, Unruh

The work performed in this objective makes our project the best source of information for the effect of a wide range of floral volatiles and herbivore-induced plant volatiles on natural enemies on different crops in widely separated locations. In addition, the factorial design of our experiments allowed us to evaluate how different potential attractants work together and give us a much more complete picture of how to combine several different volatile components together to make lures that are not only more attractive, but also more selective for different natural enemy groups. We found that 2-phenyl-ethanol (PE) was highly attractive to several species of syrphid species, and some selectivity between species was possible by adding either methyl salicylate (MS) or geraniol (GER). Lacewings (*Chrysoperla plorabunda*) responded strongly to a variety of volatiles and optimal attraction required lures combining three different volatiles. However, because of interactions between the different volatiles, there were multiple combinations that provided the same response. Acetaphenone (AP) was important for *C. plorabunda*, but only when mixed with other components. A broad range of Hymenopteran taxa responded to virtually any lure combination that contained phenylacetaldehyde (PAA) as one component.

Benefits to Science and the Agricultural Industries
Our studies showed an astonishing variety of natural enemies could be found at various times and abundances in agro-ecosystems. For example, in apple we regularly monitored >120 different natural enemies. The traps are very sensitive indicators of species presence and abundance that may change our basic understanding of population interactions. Our studies also showed that particular lure combinations work regardless of the crop system, which means that our research should translate to other crop systems which often share similar generalist natural enemies. The discovery that PAA was attractive to all hymenopterans (including honeybees) makes that compound a particularly powerful tool for studying ecosystem function because of the importance of the parasitic Hymenoptera in regulation of a wide range of insect pests.

From the standpoint of benefit to the industries, we now have sensitive traps that work for monitoring a range of natural enemy groups important in apple, cherry, pear, and walnut orchards in the western region. These traps can provide the information on natural enemy abundance throughout the season (useful in model development (objective 2)), and for understanding the effects of different control tactics on natural enemy population dynamics. Our research also showed that syrphid flies and lacewings could be used as indicator species to help simplify trap use for pest management purposes.

Which lures work best?

- **C. nigricornis**
  - Squalene
- **C. plorabunda**
  - AA+MS+PE
  - AA+AP+PE
  - AA+AP+PAA
- **PE**
  - PE+GER
- **MS+PE**
- **Scavea pyrastri**
- **Ichneumonid**
  - PAA+PE+AP

Any lure with PAA

- **honeybee**
- **Eulophid**
- **Figitid**
- **Pteromalid**
- **Seclionid**
### Three Predator Groups are Dominant

#### 4. Predation On Codling Moth

Unruh

Previous studies suggested that predation rates on mature codling moth larvae were 30 – 40% when pesticide use was moderate. Here we designed a study to identify which predator groups contribute most to codling moth mortality. Molecular gut content analysis was chosen because predators usually eat their prey and leave little visual trace of their activities. Our detection of codling moth DNA in predators provided a semi-quantitative measure of what proportion of each predator group had recently fed on codling moth. The results are conservative because digestion of the codling moth (and consequently their DNA) within the predator limits detectability to just a few days. Even so, we found earwigs, spiders, and carabid ground beetles were important due to their abundance and high feeding rates on codling moth (right).

**Benefits to Science and the Agricultural Industries**

Molecular gut content analysis of prey DNA is not new to science, however it is expensive. One technique developed during this grant has streamlined and reduced the cost of sample processing that will allow future studies to analyze significantly more specimens. As agricultural entomologists, we generally know which groups of predators were likely to be important but the activity by earwigs was both a surprise and a minor concern for some members of the industry. In some apple varieties, earwigs can sporadically cause minor fruit damage. Earwigs are well known to be important predators of woolly apple aphid, an increasingly important pest in newer apple plantings. Future studies to evaluate how earwigs may affect fruit damage compared to their contribution to overall biological control will be important knowledge for the design of sustainable IPM programs in tree fruits.

#### What is the Cost of Enhanced Biocontrol?

##### 5. Economic Analysis

Gallardo, Brunner, Castagnoli, Grant

**Benefits to the Agricultural Industries**

The economic analysis showed that both apple and pear growers were willing to pay extra for insecticides that would preserve natural enemies. Surveys showed that apple growers were willing to pay $26.60/acre to decrease toxicity to natural enemies, $61.83/acre to be less toxic to wildlife and $43.10 to decrease toxicity to aquatic organisms. Pear growers showed different trends with a willingness to pay $33.37/acre to decrease toxicity for natural enemies, $25.28/acre for decreased toxicity to wildlife and $19.68/acre for reduced toxicity to aquatic organisms.

A second analysis focused on how the use of pesticides disruptive to natural enemies affected costs of controlling secondary pests. Examination of spray records for seven apple orchard operations in Washington found that for every $1 spent on insecticides that were toxic to natural enemies, an additional $0.52 was spent on secondary pests. Similarly, analysis of the spray records for 10 pear orchards in the Hood River of Oregon showed that for every $1 spent on disruptive materials that $0.47 was required to control secondary pests.

Both of these studies show that economic incentives exist to conserve natural enemies and that growers and IPM practitioners recognize and are willing to pay to enhance biological control.
Getting the Results to the Users

6. Outreach
Brunner, Goldberger, All participants

Benefits to the Agricultural Industries
A large amount of this project’s resources were dedicated to outreach activities, highlighting the importance the project participants put on this aspect of the project. Without effective outreach activities the results generated by projects such as this one generate new scientific information, but do little to change perceptions and practices of stakeholders. The goal of the outreach objective was not just to develop knowledge and technology for the apple, pear and walnut industries, but to integrate this information with older information and deliver it in a way that would impact their decision-making and management practices.

In the final year of our project we focused our activities in two major areas, hands-on mini-workshops and further development of web resources. We knew from research that students retain new information better when they are actively involved in the learning process. Therefore, the hands-on mini-workshops involved meeting with small groups from key industry organizations, especially those shown to be early adopters of new knowledge and technology, were conducted in an engaging and interactive way. We held 10 mini-workshops over the winter of 2012/13 that included a total of 175 participants. We anticipate more rapid adoption of basic and new biocontrol information and practices through these hands-on educational activities. For the workshops, we developed hand-out materials including natural enemy fact sheets as well as a 19 x 13-inch natural enemy wall poster, which has been very popular with workshop participants and at grower meetings. These hand-out materials can also be downloaded from our project website.

Web Resources – a Legacy for the Future
Preserving our project results and providing useful resources for our stakeholders has been a top priority of this project from the start. We’ve tried to stay ahead of the changes in digital technology by frequently updating our web platform and it is currently available on nearly any platform/device combination. The website (enhancedbiocontrol.org) is a repository of all of the research results from the project’s different objectives in many forms. For Washington growers, the information generated by the project is also being incorporated into the WSU-Decision Aid System (das.wsu.edu) which is used to make IPM decisions on >80% of Washington tree fruit acreage.

In addition to comprehensive reports, the project website contains a listing of all related publications with links for reading, printable identification guides, workshop handouts, viewable presentations, natural enemy image galleries, videos of techniques and collaborator insights, and an interactive pesticide effects table developed from the results obtained in Objective 1, as well as a compiled database of pesticide effects on natural enemies that will be placed both on our project web site and the WSU-DAS website. The website will remain accessible well beyond the end of this project and thanks to new leveraged funding, we will continue to update and add features making it an enduring legacy.
It’s More Than Just What we Started to do. Just a few Examples:

Leveraged Funding Projects


This project will provide for more hands-on workshops as well as an online course that will focus on the basics of biocontrol, key natural enemies in orchards, newly developed tools to monitor and predict natural enemy presence, and pesticide effects on natural enemies; all knowledge gained from this SCRI project. We will also create an innovative and user-friendly pest and natural enemy identification guide available online and as a mobile app to complement the on-line course. In addition, the funding will allow us to extend work performed over the past 2 years with IPM practitioners to evaluate new natural enemy monitoring tools in their orchards and provide feedback. The new project’s outcomes have the potential to benefit the entire tree fruit industry through increased awareness and utilization of biocontrol resulting in reduced pesticide applications/costs and increased worker, food, and environmental safety.


This project is focused on evaluating if the use of mating disruption for CM in pears allows improved biological control of pear psylla during the summer. It will use a combination of the technologies developed in objectives 1-3 from our SCRI project to help tease apart which natural enemies are more common and the best ways to conserve the natural enemies important in pear psylla population suppression.


This project used the attractant lures developed in objective 2 of the SCRI grant. We focused on the differences in the natural enemy complexes in paired organic and conventional orchards. The data from this project were taken in the same manner as used in our studies done in the SCRI grant in objective 2, which expands the data available to make natural enemy models. The work done under this project also showed that we could use conventional pesticides at low rates (10% field rate) with timing and treatment intervals similar to organic treatments and still achieve commercially acceptable damage levels similar to either organic or conventional programs. The low rate treatments had similar natural enemy abundance and diversity as the organic treatments at a very low cost and with an 80% reduction in pesticides applied.


These two grants are aimed at improving the WSU-Decision Aid System (DAS), by incorporating models developed using data from the the SCRI project and by collecting more data to generate new models of not only natural enemies, but also pests. These grants also provided funds to enhance our outreach efforts to users throughout the state of Washington, develop orchard management systems to help minimize pesticide use in orchard systems, and to develop push notifications so that growers are alerted immediately when critical IPM events occur or are predicted to occur.


This grant is a spinoff from Objective 1 of the SCRI grant. Both the large scale field trials and the lab trials were difficult, very expensive, and prone to problems associated with year-to-year variation in pest and natural enemy population levels. This leveraged project uses field-aged residues to monitor how pesticides degrade over time and combines those data with state-of-the-art demographic models that mimic the phenology found in the field. These models then allow us to evaluate the effects of different treatment regimes for pests to evaluate the best ways to reduce pest populations while preserving natural enemy populations.
**Project Output**

**Presentations:** 2013

Amarasekare KG, PW Shearer. Comparing effects of newer insecticides on two green lacewings species, *Chrysoperla johnsoni* and *Chrysoperla carnea* (Neuroptera: Chrysopidae). Orchard Pest and Disease Management Conference, Portland, OR.

Astorino J, R. Torcasso, J Goldberger. The influence of social networks, environmental consciousness, and farm structure on the adoption of a sustainable agriculture practice. Joint Meeting of the Agriculture, Food and Human Values Society and Association for the study of Food and Society. East Lansing, MI.


Beers EH. Woolly Apple Aphid: All you wanted to know, and more…. Northwest Wholesale Recertification Day, 15 Jan., Wenatchee, WA. (invited speaker).


Jones VP. Alternative methods of codling moth control. Columbia Fruit IPM meeting. 13 Feb. (invited speaker)


Shearer PW. Enhancing biological control in western USA pear orchards. Department of Horticulture. Oregon State University, Corvallis, OR. Mar. 4. (invited seminar)

Unruh TR. Major predators of codling moth: Earwigs can be your friend. Wilbur Ellis, Organic pest consultants and growers meeting, Prosser, WA. Dec.

**2012**


Beers EH. Management of secondary and invasive pests. WSU Government Relations Committee, Wenatchee, WA.

Beers EH. Secondary pests of commercial fruit orchards. Blue Mountain Horticultural Society, 1 Feb., Milton-Freezwater, OR


Gadino AN, VP Jones, JF Brunner, EH Beers, K Gallardo, J Goldberger, NJ Mills, PW Shearer, S Castagnoli, DR Horton, TR Unruh. Enhancing biological control to stabilize western orchard IPM programs. Western Orchard Pest and Disease Management Conference, Portland, OR. 11-13 Jan.


Gadino AN, VP Jones, JF Brunner, EH Beers, K Gallardo, J Goldberger, N Mills, PW Shearer, S. Castagnoli, DR Horton, TR Unruh. Enhancing BC to stabilize western orchard IPM and a clicker survey of BC practices in orchards. Lake Chelan fruit education meeting. Lake Chelan, WA. 16 Jan. (invited speaker)

Gadino AN, VP Jones, JF Brunner, EH Beers, K Gallardo, J Goldberger, N Mills, PW Shearer, S. Castagnoli, DR Horton, TR Unruh. Enhancing BC to stabilize western orchard IPM. North Central Washington Fieldman’s Association. 1 April. Wenatchee, WA. (invited speaker)


Jones VP. How a perfect storm of technology, legislation, and applied ecology can potentially lead to IPM in Western Orchards. Purdue University, Dept. Entomology seminar, West Lafayette, IN. 11-13 Apr. (invited speaker)

Jones VP. How a perfect storm of technology, legislation, and applied ecology can potentially lead to IPM in Western Orchards. UC Davis, Dept. Entomology seminar, Davis, CA. 24-25 Apr. (invited speaker)

Jones VP. Information transfer using low and high technology. Afghan Executive Management training course. Wenatchee, WA. 13 Sept. (45 min presentation)
control in pear orchards. Winter Horticulture Meeting, Oregon State University Extension Service, Hood River, OR.

Amarasekare KG, PW Shearer, N Allum, A Borel. Laboratory bioassays to estimate lethal and sublethal effects of newer insecticides on the green lacewing Chrysoperla carnea. National Entomological Society of America (ESA) meeting, Reno, NV. 13 Nov.

Amarasekare KG, PW Shearer. Effects of pesticides on lacewings and Deraeocoris brevis: conserving important pear natural enemies. OSU Mid-Columbia Research and Extension Center Field Day, Hood River, OR. 20 July.


Chambers U, VP Jones. Biological control and the WSU Decision Aid System. WA Hort. Assoc. 6 Dec.


Gallardo RK. Economics of biological control in orchards. OSU Mid-Columbia Research and Extension Center Field Day, Hood River, OR. 20 July.


Gallardo RK. Economics of biological control. WA Hort. Assoc. 6 Dec.


Goldberger J. Pear survey results and the implications for information transfer. OSU Mid-Columbia Research and Extension Center Field Day, Hood River, OR. 20 July.

Gontijo L, EH Beers, WE Snyder. Impact of flowering plants on syrphid attraction and woolly apple aphid suppression. Western Orchard Pest and Disease Management Conference, Portland, OR. 8-10 Jan.


Jones VP. Natural enemy lures and phenology models. OSU Mid-Columbia Research and Extension Center Field Day, Hood River, OR. 20 July.


Jones VP. Delivery of science-based information. WA Hort. Assoc. 5 Dec.

Jones VP. Predicting when natural enemies are present. WA Hort. Assoc. 6 Dec.


Mills NJ. Pesticide effects on natural enemies. OSU Mid-Columbia Research and Extension Center Field Day, Hood River, OR. 20 July.

Mills NJ. Effects of pesticides on natural enemies. WA Hort. Assoc. 6 Dec.


Shearer PW. Field studies of pesticide effects on natural enemies. OSU Mid-Columbia Research and Extension Center Field Day, Hood River, OR. 20 July.

Shearer PW, K Amarasekare, VP Jones, SA Steffan. Improving biological control of insect pests of cherry. OR/WA Cherry Research Review. Hood River, OR. 7 Nov.


2010


Jones VP. Enhancing biocontrol in Western orchards: an overview. Wash. State Horticultural Assoc. 7 Dec. Yakima, WA. (invited speaker)


Jones VP. Conservation BC in Western Orchard Crops: A comprehensive approach. WRCC 2185 Annual Meeting, Coeur d’ Alene, ID. Oct. 25 (invited speaker)

Jones VP and SA Steffan. Update on the USDA Specialty Crops Research Initiative project on “Enhancing Biological Control in Western Orchards”. WSU-Sunrise Research Orchard Field Day. 29 July.


Jones VP, U Chambers, B Petit. WSU-DAS and virtual weather stations. SAGES Climate Change Meetings, Vancouver, BC. 24 March 24. (invited speaker)


2009

Steffan SA. Biocontrol Innovation at the WSU Tree Fruit Research and Extension Center. WSU Tree Fruit Field Day. 22 July.

Unruh TR. Enhancing western orchard biocontrol. WSU Tree Fruit Field Day. 15 July.

Steffan SA. Biocontrol in Pacific NW Orchards. Pest Management Transition Project outreach meetings in north central WA. 28 May, 3 June, 10 June.

Symposia presentations: 2014

We organized symposium entitled “Progress towards integration of conservation biological control in Western apple, pear, and walnut orchards” on our project for the Pacific Branch of the Entomological Society of America that will be presented at the Tuscon meetings in 7-10 April with the following titles and speakers:

Jones VP. Enhancing biological control in Western apple, pear, and walnut orchards.


Mills NJ. Comparative analysis of pesticide effects on natural enemies in Western orchards: a synthesis of laboratory bioassay data.

Beers EH. Natural enemies and non-target effects: Do lab results predict field results?

Unruh TR. A broader approach to gut content analysis for better understanding of predator diets.

Shearer PW, K Amarasekare, S Castagnoli. Assessing conservation biological control in Mid-Columbia pear orchards.

Brunner JF, K Gallardo. Assessing the economic value of biocontrol in western orchard systems.

Goldberger J. Who uses biological control and why? Evidence from surveys of walnut and pear growers in the western US.

Gadino A. Developing an outreach program for a regional, multi-year grant: lessons learned and future directions.

Chambers U. Making new information accessible to the stakeholders through websites, decision support systems and smartphone apps.

2013


2012

Beers EH. Biocontrol and IPM: the key component or the missing link? Pacific Branch Entomological Society of America, Portland, OR. 26-28 March.


Smith TJ, VP Jones. Effects of sublethal pesticide residues on the dispersal capabilities of coding moth (Cydia pomonella) and obliquebanded leafroller (Choristoneura rosacea). Pacific Branch Entomological Society of America, Portland, OR. 26-28 Mar.

2011

Approaches for Insect Pest Management. 13 Nov.

2010
Brunner JF, MD Doerr. Control of direct pests of organic apples: Successes and challenges. Symposium presentation, Pacific Branch of the Entomological Society of America’s 94th annual meeting, Boise, ID. 11-14 April.

Jones VP, SA Steffan, DR Horton, NJ Mills, PW Shearer. Enhancing BC in organic orchards using HIPV lures to characterize, monitor and manipulate natural enemies. Symposium presentation, Pacific Branch of the Entomological Society of America’s 94th annual meeting, Boise, ID. 11-14 April.

Mills NJ. Predation of syrphids in organic prunes: How many predators are enough? Symposium presentation, Pacific Branch of the Entomological Society of America’s 94th annual meeting, Boise, ID. 11-14 April.

Shearer PW. Peach Orchard ground cover management mitigates bug damage. Symposium presentation, Pacific Branch of the Entomological Society of America’s 94th annual meeting, Boise, ID. 11-14 April.

Unruh TR. Who’s eating whom? Evaluating predators and parasitoids and the influence of the farmscape using protein-marking and gut content analysis. Pacific Branch of the Entomological Society of America’s 94th annual meeting, Boise, ID. 11-14 April.

Steffan SA, VP Jones, CC Baker, and TD Melton. Chumming for predators: HIPV lures as monitoring tools for natural enemies. Pacific Branch of the Entomological Society of America’s 94th annual meeting, Boise, ID. 11-14 April.

Unruh TR. Key predators of codling moth. Pacific Branch of the Entomological Society of America’s 94th annual meeting, Boise, ID. 11-14 April.

National Symposium (2010)
We presented a 3 hour symposium on our project at the Entomological Society of America Annual Meeting in San Diego, CA (15 Dec 2010) entitled “Building the Framework to Enhance Biological Control in Orchard System: Progress and Problems in the Western U.S.” - 10 presentations:

- Jones VP. Overview and information needed to integrate conservation BC into orchard systems.
- Steffan SA, VP Jones, CC Baker, TD Melton. Use of HIPV lures to evaluate natural enemy abundance, diversity and phenology.
- Mills, NJ. How do we estimate direct and indirect effects of pesticides on BC? An overview of problems and solutions.
- Amarasekare KG, PW Shearer. Use of laboratory assays to estimate pesticide effects on BC agents.
- Beers EH, L Gontijo. Connecting the dots: do laboratory bioassays predict disruption of BC in the field?
- Goldberger J, N Lehrer. Use of grower surveys to evaluate BC adoption and knowledge transfer.
- Chambers U, VP Jones, JF Brunner, B Petit. Decision support systems as a method to enhance adoption of BC.
- Brunner JF, C Pickel, S Castagnoli, K Lewis, P van Buskirk, WE Jones, TJ Smith. Synthesis and outreach programs: leaving a legacy useful to growers and consultants.

2009
Beers EH. Cover Crops: Inviting Natural Enemies into Your Orchard. Int. IPM Symposium. Portland, OR. 24-26 March. (invited speaker)


Jones VP. Using pest and natural enemy nology to enhance biological control in orchards. Int. IPM Symposium. Portland, OR 24-26 March. (invited speaker)

Jones VP, JF Brunner, GG Grove, WE Jones, U Chambers, JF Brunner. Lethal and sublethal effects of insecticides on leafroller, Chrysoperla carnea. Centennial Celebration and Annual Open House - Research Highlights. Mid-Columbia Agricultural Research and Extension Center, Oregon State University, Hood River, OR.

Unruh TR. Measuring predation on codling moth. Western Orchard Pest and Disease Conference, 11-13 Jan. Portland, OR

2012
biological control to stabilize Western orchard IPM systems. WSU Sunrise Field Day, Wenatchee, WA. 16 Aug.


2010

Amarasekare KG, PW Shearer and AA Borel. Effects of newer insecticides on the natural enemy Deraeocoris brevis (Uhler) (Hemiptera: Miridae). Poster. Pacific Branch Entomological Society of America’s 94th annual meeting. Boise, ID. 11-14 April. (PDF 580KB)

Jones VP, S Steffan, JF Brunner, EH Beers, J Goldberger, K Gallardo, U Chambers, NJ Mills, DR Horton, T Unruh, PW Shearer and S Castagnoli. Enhancing Biological Control to Stabilize Western Orchard IPM Systems. Poster. WSU Academic Showcase. (PDF 8,4MB)

Popular Articles:

2013


2012

Warner, G. Watch out, codling moth! Spiders will eat anything they can physically tackle, including codling moth larvae and pupae. Good Fruit Grower. May 1.

Hansen, M. Easier access to MRLs. Visit the DAS web site. Good Fruit Grower. March 15.

Warner, G. Let natural enemies play a role. IPM means managing pests, not eliminating them. Good Fruit Grower. February 1.

2011

Wheat D. Entomologist makes research relevant. Capitol Press. 22 April. (Jones interview)

Clark B. Entomologists open new frontiers to aid sustainable future for for fruit growers. WSU On Solid Ground. 25 May. (Jones, Brunner, Beers interview).

Warner G. $4.5M project. Good Fruit Grower. 15 March. (Jones interview)

Warner G. Watch out for the good guys: Biological control is more important than people realize. Good Fruit Grower. 15 March. (Jones interview)

Warner G. Scientists study pesticide effects: The choice and timing of pesticide sprays can influence biological control. Good Fruit Grower. 1 April. (Mills interview)

Warner G. Who’s eating codling moth. Good Fruit Grower. 15 April. (Unruh interview)

Warner G. Counting the benefits of biocontrol. Good Fruit Grower. 1 May. (Gallardo, Brunner interview)

Warner G. Who’s making the decisions. Good Fruit Grower. 15 May. (Goldberger interview)

Clark B. The model makers. WSU CAHNRS and Extension Alumni and Friends Connections Magazine. Fall 2011. (Jones interview)

2010


Refereed Publications

2014

We have contacted the journal Biological Control and arranged for the publication of a special issue with 14 different articles (below) all by our team members. These articles will go through the normal peer review process and be published together in a single issue devoted to our project. This method of publication brings our work together in a single location available in the best libraries in the world as well as available on the internet.


erla carnea (Neuroptera: Chrysopidae). Environmental Entomology. (in press)


Amarasekare KG, PW Shearer. 2013. Laboratory bioassays to estimate the lethal and sublethal effects of various insecticides and fungicides on Deraeocoris brevis (Hemiptera: Miridae). J. Economic Entomol. 106: 776-785.


Wiman NG, VP Jones. Sublethal effects of pyriproxyfen and methoxyfenozide on Nemorilla pyste and Nilea erecta (Diptera: Tachinidae), parasitoids of leafrollers (Lepidoptera: Tortricidae) in tree fruits. J. Pest Management Sci. (in press)


Jones VP, NG Wiman 2012. Modeling the interaction of physiological time, seasonal weather patterns, and delayed mating on population dynamics of codling moth, Cydia pomonella (L.) (Lepidoptera: Tortricidae).

Smith TJ. 2012. Effects of flight and sublethal pesticide residues on codling moth (Cydia pomonella (L.)), obliquebanded leafroller, Choristoneura rosaceana (Harris), and convergent ladybird beetle, Hippodamia convergens (Guérin-Méneville). MS Thesis, Washington State University, Department of Entomology, Pullman, WA.


2010


2009


M Misc. Outreach

Amarasekare KG. KIHR- (Local Radio Station, Hood River, OR) - Radio Talk on enhancing biological control in tree fruit orchards. 5 Jan.

Shearer PW. KIHR - (Local Radio Station, Hood River, OR). Radio Talk Biological control: using good bugs to take care of bad bugs. Jones VP. The future of IPM in orchard crops. 15 min. video, part of the series by the University of California program on Extending Orchard IPM knowledge in California. 11 April 2013. http://ucanr.edu/sites/orchardIPM/Video_Library赛车?

Meetings Attended/Hosted

2013


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- University of California at Berkeley
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Grower Cooperators:
- California Walnut growers of Suisun Valley, Davis and Chico.
- Oregon Pear Growers in Hood River
- Washington apple growers in Quincy, Bridgeport, Frenchman Hills, Yakima, and Wapato.

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Brunner Lab (Obj. 6)
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