center for pollinator research

third international conference
on pollinator biology, health & policy
july 18 - 20 2016
pennsylvania state university

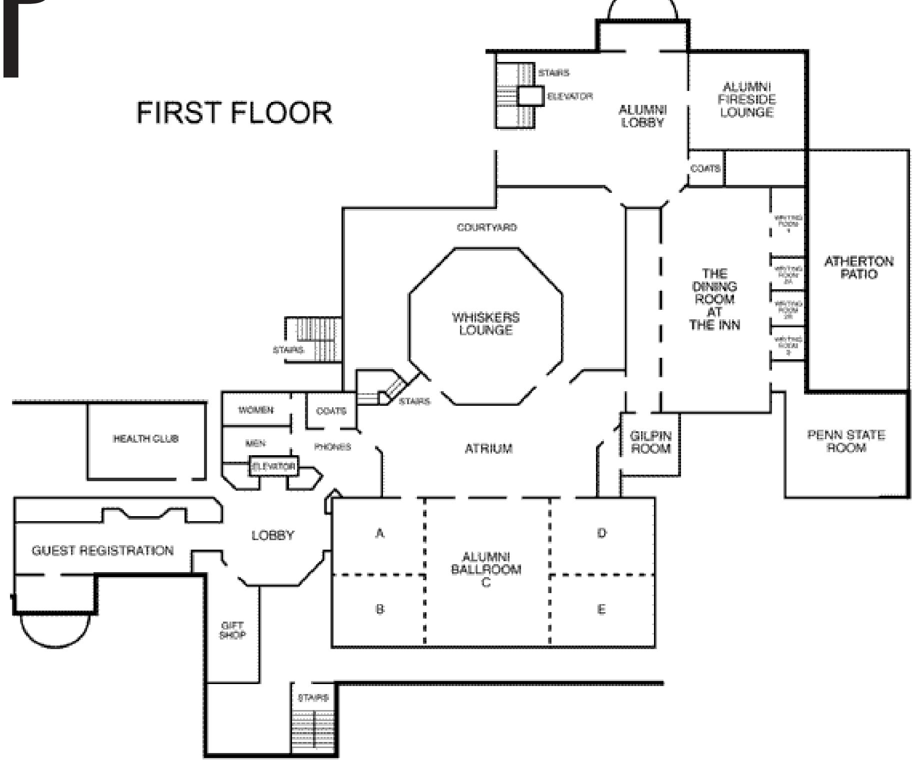
The conference organizers would like to thank

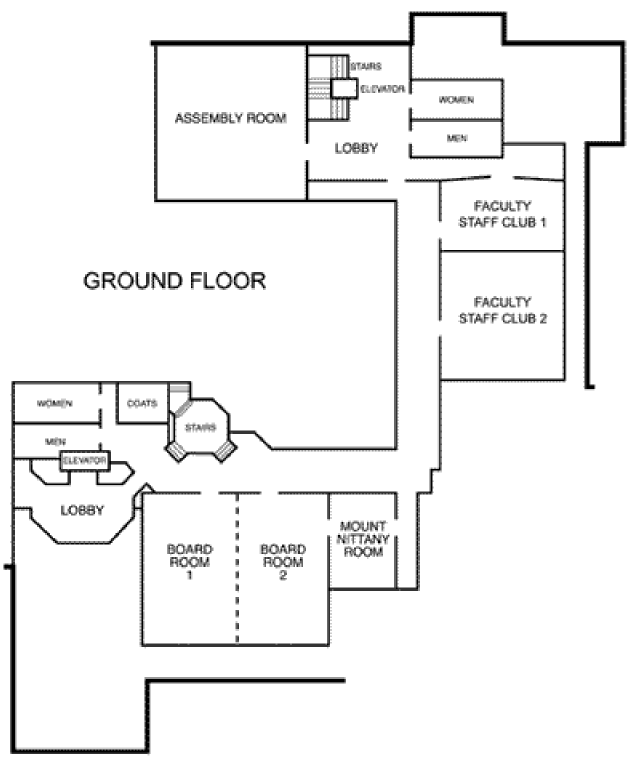
Harland M. Patch

for the graphics used on the front cover
of the program booklet and the conference bags.

CONTENTS

MAP


FIRST FLOOR
STAIRS
ELEVATOR
ALUMNI LOBBY
ALUMNI FIRESIDE LOUNGE
COATS
COURTYARD
WHISKERS LOUNGE
THE DINING ROOM AT THE INN
ATHERTON PATIO
STAIRS
STAIRS
WOMEN
COATS
MEN
PHONES
ELEVATOR
ATRIUM
GILPIN ROOM
PENN STATE ROOM
HEALTH CLUB
GUEST REGISTRATION
LOBBY
A
D
ALUMNI BALLROOM C
B
E
GIFT SHOP
STAIRS


STAIRS
ELEVATOR
ASSEMBLY ROOM
WOMEN
MEN
LOBBY
FACULTY STAFF CLUB 1
GROUND FLOOR
FACULTY STAFF CLUB 2
WOMEN
COATS
STAIRS
MEN
ELEVATOR
LOBBY
BOARD ROOM 1
BOARD ROOM 2
MOUNT NITTANY ROOM

SUNDAY

6:00 PM – 9:00 PM	**Evening Reception** *Alumni Lounge and Lobby, Nittany Lion Inn*

MONDAY

7:00 AM – 10:00 AM	**Registration check in** *Outside Ballroom*
7:30 AM – 8:20 AM	**Breakfast** *Outside Ballroom*
8:20 AM – 8:30 AM	**Opening remarks** *Ballroom*
8:30 AM – 9:30 AM	**Keynote 1** **Perfect Storm to Nutritional Security: Role of Pollinators** Sonny Ramaswamy, USDA-NIFA *Ballroom*
	Symposium 1: **Epidemiology and modeling of global pollinator populations** Co-moderators: Christina Grozinger and Dennis vanEngelsdorp Plenary: Dennis vanEngelsdorp *Ballroom*
9:30 AM – 10:10 AM	**Untangling the drivers of honey bee losses: An epidemiological approach** Dennis vanEngelsdorp, University of Maryland
10:10 AM – 10:30 AM	**The international SMARTBEES project - preserving the biodiversity of honey bees in Europe and developing sustainable strategies for the Varroa problem** Marina Meixner, Bieneninstitut Kirchhain, Germany
10:30 AM – 10:50 AM	**Break**
10:50 AM – 11:10 AM	**Modelling the consequences of individual responses to stress on honey bee colony function** Andrew Barron, Macquarie University, Australia
11:10 AM – 11:25 AM	**Transcriptomic approaches to identify and rapidly diagnose novel viruses infecting bee populations worldwide** Dave Galbraith, Penn State University

11:25 AM – 11:40 AM	**Pathogen Prevalence in Plant-Pollinator Networks** Laura Figueroa, Cornell University
11:40 AM – 11:55 AM	**A pan-European epidemiological study reveals honey bee colony survival depends on beekeeper education and disease control** Marie-Pierre Chauzat, ANSES
11:55 AM – 12:15 PM	**National Survey of Honey Bee Pests and Diseases** Robyn Rose, USDA-APHIS
12:15 PM – 1:30 PM	**Lunch** *Alumni Lounge and Lobby*
	Symposium 2: Bees, Landscapes, and Ecosystem Services Co-moderators: Shelby Fleischer and Rachael Winfree Plenary: Taylor Ricketts *Ballroom*
1:30 PM – 2:10 PM	**Modeling crop pollination services at local, landscape, and national scales** Taylor Ricketts, University of Vermont
2:10 PM – 2:30 PM	**Direct and indirect effects of soil eutrophication on pollination services** Luisa Carvalheiro, University of Brasilia
2:30 PM – 2:50 PM	**Quantifying the importance of two mechanisms, response diversity and cross-scale resilience, in stabilizing crop pollination services** Dan Cariveau, University of Minnesota
2:50 PM – 3:20 PM	**Break**
3:20 PM – 3:40 PM	**The Elephants and Bees Project: Using Bees as a Natural Deterrent for Crop-Raiding Elephants** Lucy King, Save the Elephants, Kenya
3:40 PM – 4:00 PM	**Honey Bee Health and the landscape: Feasts, Famines, and Solutions** Zac Browning, American Beekeeping Federation
4:00 PM – 4:15 PM	**Simultaneously enhancing native pollinators and crop yield: conservation in agroecosystems** Laura Russo, Penn State University
4:15 PM – 4:30 PM	**Quantifying the impact of species invasions and extinctions on pollination services in a diverse island ecosystem** Anna Johnson, University of Pittsburgh
5:30 PM	**Reception at Arboretum**

TUESDAY

7:30 AM – 8:30 AM	**Breakfast** *Outside Ballroom*
8:30 AM – 9:30 AM	**Keynote 2** **What can pollinators tell us about biodiversity and ecosystem services in real-world landscapes?** Rachael Winfree, Rutgers
	Symposium 3: Nutrition and Habitat Co-moderators: Neal Williams and Marla Spivak Plenary: Amy Toth Ballroom
9:30 AM – 10:10 AM	**Landscape and diet diversity influence bee nutritional health** Amy Toth, Iowa State University
10:10 AM – 10:30 AM	**Molecular Studies of Bumble Bee Nutrition** Sarah Hollis Woodard, University of California, Riverside
10:30 AM – 11:00 AM	**Break**
11:00 AM – 11:20 AM	**Answering the 'what, when, where, why and how' questions for pollinator habitat creation in UK agricultural landscapes** Claire Carvell, Center for Ecology and Hydrology, Wallingford, UK
11:20 AM – 11:40 AM	**Impacts of land use in the Northern Great Plains on beekeeper habitat selection and honey bee health** Matthew Smart, USGS
11:40 AM – 11:55 AM	**Stalking a stem nesting bee: a holistic perspective on wild bee habitat and nutrition** Sandra Rehan, University of New Hampshire
11:55 AM – 12:10 PM	**Impact of Seasonal Resources on Nutrient Acquisition and Gene Expression in Honey Bees** Gloria DeGrandi-Hoffman, USDA-ARS
12:10 PM – 1:30 PM	**Lunch** *Boardroom, Lower Level*

	Symposium 4: Integrated Pest and Pollinator Management Co-moderators: Ed Rajotte and Rufus Isaacs Plenary: Ed Rajotte Ballroom
1:30 PM – 2:00 PM	**Integrated Pest and Pollinator Management: Practical Solutions that Farmers Can Live With** Ed Rajotte, Penn State
2:00 PM – 2:20 PM	**Unexpected consequences of neonicotinoid seed treatments reveal opportunities for IPM** John Tooker, Penn State
2:20 PM – 2:40 PM	**The California Almond Experience with Best Management Practices for Growers and Beekeepers** Gabriele Ludwig, California Almond Board
2:40 PM – 2:55 PM	**Strategies for sustainable management and propagation of the blue orchard bee in tree fruit orchards** Natalie Boyle, USDA-ARS, Utah
2:55 PM – 3:20 PM	**Break**
3:20 PM – 3:40 PM	**Integrating Pest and Pollinator Management for Lawns, Ornamental Landscapes, and Golf Courses** Dan Potter, University of Kentucky
3:40 PM – 3:55 PM	**Threat to an ecosystem service: pesticide induced impairment to individual and colony level traits in social bees** Richard Gill, University of London, UK
3:55 PM – 4:10 PM	**Managing farms and landscapes for both biological control and pollination services** Heather Grab, Cornell University
4:10 PM – 4:20 PM	**Genetic diversity of restricted wild bumblebees (Bombus) was already low a century ago before the agricultural intensification: a case study in Belgium with historical specimens (1913-1915) with recent ones (2013-2015)** Guy Smagghe, Ghent University
5:30 PM	**Poster reception** *Ballroom*

WEDNESDAY

7:30 AM – 8:30 AM	**Breakfast** *Outside Ballroom*
8:30 AM – 9:30 AM	**Keynote 3** **Understanding the Relationship Between Genes and Social Behavior: Lessons from the Honey Bee** Gene Robinson, University of Illinois, Urbana-Champaign
	Symposium 5: Molecular Tools for Managing Pollinator Populations Co-moderators: Shalene Jha and Elina Lastro Niño Plenary: Mark Brown *Ballroom*
9:30 AM – 10:10 AM	**Tracking parasites, pathogens, and disease in pollinators: the potential and pitfalls of molecular approaches** Mark Brown, University of London, UK
10:10 AM – 10:30 AM	**Honey bee viruses, colony health, and antiviral defense** Michelle Flenniken, Montana State University
10:30 AM – 11:00 AM	**Break**
11:00 AM – 11:20 AM	**Advancing our understanding of honey bee queen reproduction and potential applications for beekeepers** Elina L. Niño, University of California-Davis
11:20 AM – 11:40 AM	**GWAS for marker-assisted selection and studying colony level traits in Honey bees** Amro Zayed, York University
11:40 AM – 11:55 AM	**Effects of Urbanization on Diseases and Immunocompetence of Native Bees** Margarita Lopez-Uribe, North Carolina State University
11:55 AM – 12:10 PM	**Pollinator Community Composition Influences Virus Prevalence in Honey Bees and Native Bees** Michelle L. Fearon, University of Michigan
12:10 PM – 1:30 PM	**Lunch** *Alumni Lounge/Lobby*

	Symposium 6: Education and Outreach Co-moderators: Vicki Wojcik, Pollinator Partnership and Katharina Ullmann, Xerces Society for Invertebrate Conservation Joint Plenary Speakers: Vicki Wojcik and Katharina Ullmann *Ballroom*
1:30 PM – 1:32 PM	**Welcome**
1:32 PM – 2:01 PM	**Engaging Stakeholders in Pollinator Support on Corridors and Utility Lands** Vicki Wojcik, Pollinator Partnership
2:01 PM – 2:30 PM	**Engaging stakeholders and using multiple communication strategies to develop effective pollinator outreach programs and tools** Katharina Ullmann, Xerces Society for Invertebrate Conservation
2:30 PM – 2:50 PM	**Penn State Master Gardener Pollinator Friendly Garden Certification Program** Constance Schmotzer, Penn State Extension
2:50 PM – 3:10 PM	**Conserving Monarch Butterflies through Education, Outreach, Research and Monitoring** Holly Holt, Monarch Joint Venture
3:10 PM – 3:30 PM	**Decision modeling to support pollinator-based fruit farm management** Eric Lonsdorf, Franklin and Marshall College
3:30 PM – 3:50 PM	**The Maine Bumble Bee Atlas: A Multi-Year Citizen Science Project to Survey Bumble Bee Species in Maine** Kalyn Bickerman-Martens, University of Maine
3:50 PM – 4:10 PM	**Brain Buzz: A framework for exploring pollination systems knowledge of undergraduates** Doug Golick, University of Nebraska-Lincoln
4:10 PM – 4:30 PM	**The Northeast Pollinator Partnership** Maria van Dyke, Cornell University

MONDAY SPEAKERS

SUN MON TUE WED

Perfect Storm to Nutritional Security: Role of Pollinators

Sonny Ramaswamy

Director, National Institute of Food and Agriculture, Washington, DC 20250

Earth's population is expected to exceed well over 9 billion by 2050, and we will need to meet humanity's need for food, feed, fuel, fiber, and shelter, with a minimal ecological footprint. The "9 Billion Problem" has implications for how we grow and view food now and in the future. Pollinators are a significant part of the toolkit to create a sustainable path forward to address humanity's nutritional security. Combining significantly improved knowledge of pollinator biological systems with cyberphysical systems, sensors, and Big Data tools will offer us unparalleled capacity and insights to mitigate the abiotic and biotic constraints that may significantly impact pollinators and our ability to achieve nutritional security.

The National Institute of Food and Agriculture (NIFA) supports research, education, and outreach aimed at solving the grand global challenges, including nutritional security, food safety, sustainable energy, water, and climate change, ultimately ensuring the economic well being of communities.

Untangling the drivers of honey bee losses: An epidemiological approach

Dennis vanEngelsdorp

Assistant Professor, University of Maryland, Department of Entomology, Dvane@umd.edu, Beeinformed.org

Honey bees are dying. In the US, they have been dying at high rates for the last 10 years. What's going on? Here we summarize 10 years of honey bee health surveillance data in an attempt to identify factors that contribute to colony mortality and morbidity. Further we will explore the interactions between these factors which include parasites, pathogens, pesticides and poor nutrition.

But, the role of the epidemiologist is not just to identify risk factors that may contribute to poor health, but also identify ways to mitigate these risks factors in order to promote greater health. In keeping with this goal, we present different approaches to encourage honey bee health. While these approaches include individual beekeeper management practices, we will argue that they also require landscape level changes. In short, keeping bees healthy may take a village.

The international SMARTBEES project - preserving the biodiversity of honey bees in Europe and developing sustainable strategies for the Varroa problem

Marina D. Meixner

LLH Bee Institute Kirchhain, Germany, Marina.meixner@llh.hessen.de

Numerous subspecies of *Apis mellifera* are native to Europe. Coordinated selective breeding for traits of commercial interest, however, exists in only two subspecies (*A. m. carnica* and *ligustica*), while breeding and improvement efforts are virtually absent in all other ones. In consequence, native populations in many regions of Europe appear ever less desirable for beekeepers, leading to mass importations and an increasing practice of queen trade across the continent. As a result, several native subspecies are affected by severe hybridization or must even be considered as endangered. In addition, recurring honey bee colony losses are noted Europe-wide, with the invasive parasitic mite *Varroa destructor* and its associated viruses known as main drivers.

The main approach of SMARTBEES can be described as promoting conservation by utilization. The objectives include the development and implementation of breeding strategies, including traits related to Varroa resistance, on the European level. The results of these efforts will improve the acceptance of local subspecies by the respective beekeeping communities. Further objectives are to identify resistance mechanisms against Varroa and virus infections and to develop genetic markers for genomic selection. By actively involving beekeepers all over Europe the project will also contribute to improving apiculture extension methods.

Modelling the consequences of individual responses to stress on honey bee colony function

Andrew B. Barron [1], Simon Klein [1,2], Clint J. Perry [1,3], Eirik Søvik [1,4], & Mary R. Myerscough [5]

1. Department of Biological Sciences, Macquarie University, Sydney NSW 2109
2. Université Paul Sabatier (UPS), Centre de Recherches sur la Cognition Animale, 31062 Toulouse, France
3. School of Biological and Chemical Sciences, Queen Mary University of London, London E1 4NS, United Kingdom
4. Department of Biology, Washington University in St. Louis, St. Louis, MO 63130
5. School of Mathematics and Statistics, The University of Sydney, Sydney, NSW 2006, Australia

Here we examined how stress responses of individual bees might change the function of the honey bee colony. A common response of honey bee workers to diverse stressors is to accelerate their normal pattern of behavioural development and commence foraging precociously. Measurements of lifetime foraging performance showed that precocious foragers completed far fewer foraging trips, had a higher risk of death in their first flights, and were less efficient than bees that commenced foraging when more than two weeks old as adults. We used a simple demographic model to explore how the poor performance of young foragers might impact colony function. In our model we considered the only direct effect of a stressor to be increased mortality of foragers. An indirect effect was a progressive decrease in the mean age and efficiency of the foraging force over time. When the foraging force could no longer support the needs of the colony there was a total breakdown in division of labour and a rapid terminal decline in population leaving just brood and some food in the hive. We believe this model sheds some light on the process of colony failure, which in turn suggests strategies to improve colony resilience.

Transcriptomic approaches to identify and rapidly diagnose novel viruses infecting bee populations worldwide

David Galbraith [1], **Joyce Sakamoto** [1], **Maryann Frazier** [1], **Yanping Chen** [2], **Diana Cox-Foster** [3], **Harland M. Patch** [1] **and Christina M. Grozinger** [1]

1. Pennsylvania State University, University Park, PA,
2. USDA - ARS, Beltsville, MD,3Pennsylvania State University, State College, PA

Honey bee populations in the United States have been in decline for decades, with beekeepers losing an average of 30% of their colonies every winter. Undoubtedly, viruses are a major contributor of these honey bee colony losses. Currently, there are more than 20 viruses that have been identified in honey bees, but certainly there are more that have yet to be identified. Indeed, recent studies have suggested that African honey bee populations host unique types of viruses. There is also evidence that some of these viruses are easily transmitted to other bee species, occurring when infected and uninfected bees forage on the same plants. These viruses are likely freely circulating among multiple bee species in a particular region, substantially increasing the threat of introduction of exotic viruses into the US. We have characterized viral populations using next generation sequencing of virus-enriched RNA from bee (including several non-*Apis* species) populations from around the world. This data will then be used to develop molecular based tools that can be used for rapid and sensitive screening of biological samples, such that we can take steps to mitigate any new virus outbreak before it threatens US pollinators and our agricultural systems and food security.

Pathogen Prevalence in Plant-Pollinator Networks

Laura L Figueroa [1], **Heather Connelly** [1], **Peter Graystock** [2], **Quinn McFrederick** [2] **and Scott McArt** [1]

1. Cornell University, Ithaca, NY,
2. University of California, Riverside, CA

Bees provide essential ecosystem services by pollinating the world's flowering plants. Growing dependence on pollinators heightens the concern regarding worldwide declines, which have been attributed in part to pathogens. Transmission of pathogens can occur via shared use of resources, which for bees include flowers. Remarkably, very little is known about how pathogen dynamics of bees relate to flowers, much less to entire plant-pollinator networks. In this study, plant-pollinator networks were developed for eleven wildflower plantings in upstate NY during summer of 2015. Bee visitation at flowers was observed on a weekly basis, and bees and flowers were collected for pathogen screening via PCR: Neogregarines, *Nosema apis*, *N. ceranae* (microsporidians), and Deformed Wing Virus (DWV). Pathogens were abundant in the system: 29.4% of flowers and 23% of bees, including at least 12 different bee species, tested positive for at least one pathogen. To the best of our knowledge, this is the first record of pollinator pathogens on wildflowers in nature. Our preliminary data suggests that 1) patterns of shared visitation at flowers may be insufficient for explaining pathogen transmission dynamics, and 2) other factors, such as specific bee and flower traits, may be more important for predicting transmission.

A pan-European epidemiological study reveals honey bee colony survival depends on beekeeper education and disease control

Antoine Jacques [1,2], Marion Laurent [2], Epilobee Consortium, Magali Ribiere-Chabert [2], Mathilde Saussac [1], Stéphanie Bougeard [3], Giles E. Budge [4,5], Pascal Hendrikx [1] and Marie-Pierre Chauzat [1,2]

1. Unit of coordination and support to surveillance, ANSES, Scientific Affairs Department for Laboratories, Maisons-Alfort, France.
2. Anses, Honey Bee Pathology Unit, European Reference Laboratory for Honey Bee Health, Sophia Antipolis, France.
4. Fera, Sand Hutton, York, UK.
5. Institute for Agri-Food Research and Innovation, Newcastle University, Newcastle upon Tyne, Tyne and Wear, UK.

Reports of honey bee population decline have spurred many national efforts to understand the extent of the problem and to identify causative or associated factors. However, our collective understanding of the factors has been hampered by a lack of joined up trans-national effort. Moreover, the impacts of beekeeper knowledge and interventions have often been overlooked. Here, we established a standardised active monitoring network (EPILOBEE) for 5 798 apiaries over two consecutive years to quantify honey bee colony mortality across 17 European countries. Our data demonstrate that overwinter losses ranged between 2% and 32%, and that high summer losses were likely to follow high winter losses. Multivariate Poisson regression models revealed that hobbyist beekeepers with small apiaries and little experience in beekeeping had double the winter mortality rate when compared to professional beekeepers. Furthermore, clinical signs of diseases were not reported on honey bee colonies kept by professional beekeepers, unlike apiaries from hobbyist beekeepers that had symptoms of bacterial infection and heavy Varroa infestation. Our data highlight, among the recorded factors, apicultural practices and beekeeper background as major drivers of the honey bee colony losses observed. The benefits of conducting trans-national monitoring schemes and improving beekeeper training are discussed.

National Survey of Honey Bee Pests and Diseases

Robyn Rose
USDA-APHIS

A decline in honey-bee health due to parasites, diseases, poor nutrition and environmental toxins has been documented for years. Under current international trade agreements, the U.S. cannot deny import permits from other nations unless the exporting nation has a disease, parasite, or pest of honey bees that is not found in the U.S. Confirming the absence of exotic threats to honey bee populations not thought to be present in the U.S. is the primary objective a national survey of honey bee pests and diseases that has been funded annually since 2009 by the United States Department of Agriculture (USDA) Animal Plant Health Inspection Service (APHIS) and coordinated in collaboration with the USDA Agricultural Research Service (ARS) Bee Research Laboratory and the University of Maryland.

Of particular emphasis of this survey is an attempt to document the likely absence of certain honey bee parasites and diseases in the US; specifically, the absence of the parasitic mite *Tropilaelaps* and other exotic threats, such as *Apis cerana* and slow bee paralysis virus (SBPV). To date, no exotic *Tropilaelaps* mites nor SBPV have been detected in the U.S. To maximize the information gained from this survey effort, collected samples are also analyzed for honey bee diseases and parasites known to be present in the US. This information will help to place current and future epidemiological studies in context and thus may indirectly help investigations of emerging conditions such as colony collapse disorder (CCD). This cross-country survey is the most comprehensive honey bee pest and health survey to date, and provides essential disease and pest-load baseline information.

Modeling crop pollination services at local, landscape, and national scales

Taylor H. Ricketts

Gund Institute for Ecological Economics, University of Vermont

As a scientific community, we've done well. Compared to other ecosystem services, we have built an extraordinarily robust evidence base for the spatial dynamics of crop pollination. Dozens of field studies are illuminating the importance of both farm-scale and landscape factors on pollinators, and regular meta-analyses are synthesizing these studies into overall findings. This provides an opportunity to develop general models to describe pollination services across landscapes. These models can be used to predict spatial patterns, temporal dynamics, and responses to changing land use and climate. In this talk I will describe one such model, and illustrate its use with applications at local, landscape, and national scales. These applications address questions like: How can a farmer optimize the location and amount of habitat enhancements? Where on a landscape would deforestation most affect pollination services to nearby farmers? Where in the U.S. are areas of likely mismatch between supply and demand for pollination services? After giving these examples, I will do my best to make several smart and thought-provoking points about remaining weaknesses and promising future directions.

Direct and indirect effects of soil eutrophication on pollination services

Luísa G. Carvalheiro

Departamento de Ecologia, Universidade de Brasilia

The intensified use of fertilizers in agriculture is one of the main causes of environmental eutrophication, potentially altering pollination services. Such effects might be caused by changes in flower-visitation patterns in the natural habitat patches that supports the crop pollinators, or by direct effects driven by crop floral resources changes. This project combines a synthesis work that evaluates how plant traits regulate flower visitation patterns under different soil nutrient levels, with field experiments in common bean agricultural fields involving different fertilization practices.

Data on >2000 flower-visitation networks was gathered from >50 independent studies from 5 continents, covering a diverse range of soil nutrient conditions. This data is used to evaluate if plant functional traits related to nutrient usage (e.g. ability to establish relations with nitrogen fixing organisms) regulate the influence that a given plant has in the pattern of visitation of pollinators. For the field evaluations, we compare flower production, nectar properties and visitation patterns in 28 sites within agricultural fields with different levels of chemical fertilizer input. The results of this study will help predict the consequences of increased nutrient availability for the pollination of different plant species, and help improve management of pollination services for agricultural production.

Quantifying the importance of two mechanisms, response diversity and cross-scale resilience, in stabilizing crop pollination services

Daniel P. Cariveau[1,2], **Mark Genung**[2], **and Rachael Winfree**[2]

1. Department of Entomology, University of Minnesota Twin Cities, St. Paul, MN 55108
2. Department of Ecology, Evolution, and Natural Resources, Rutgers University, New Brunswick, NJ 08901

Ecosystem services such as crop pollination are delivered by a diverse suite of species. As biological diversity declines, this loss may negatively affect ecosystem services. Changes in biodiversity, in general, may have two effects on ecosystem system delivery. First, it can influence the total amount of services delivered. Second, and less well-understood, is how biodiversity affects the variability (i.e. stability) of services across time and/or space. We explore two mechanisms that may stabilize variability in services: response diversity and cross-scale resilience. Response diversity is the differential response of species to the same ecological disturbance. Cross-scale resilience occurs when species' responses to the same environmental disturbance differ across spatial and/or temporal scales. Either mechanism could lead to complementarity among bee species in the pollination each provides, and thus buffering aggregate crop pollination services against environmental change. Despite the importance of this issue in the context of global change, response diversity and cross scale resilience have rarely been measured in the field and analysis methods have not been rigorously defined. We use three data sets on crop pollination by wild, native bees to define, test, and quantify the importance of response diversity and cross-scale resilience in stabilizing pollination services.

The Elephants and Bees Project: Using Bees as a Natural Deterrent for Crop-Raiding Elephants

Dr. Lucy E. King, DPhil, MSc

Head of Human-Elephant Co-Existence Program, Save the Elephants, Kenya

Research Associate, Department of Zoology, University of Oxford, UK

Elephants in Kenya are not confined to national parks and reserves; hence interactions between farmers and crop-raiding elephants can pose serious social, political, economical and conservation problems. Dr Lucy King's research has proved that African elephants are aware about, and will actively avoid, the threat of African honey bees. She demonstrated that not only do they run away from disturbed bee sounds but her team also revealed that elephants emit a unique low frequency (infrasonic) rumble that warns other elephants in the area to retreat. These rumbles appear to be novel to the threat of bees when compared to infrasonic rumbles emitted by elephants in response to human threat. These behavioural discoveries were groundbreaking, and encouraged her to develop and test a unique application for this behaviour through the use of protective Beehive Fences around farmers' fields with the aim of reducing human-elephant conflict (HEC). The Beehive Fences are not only reducing damaging crop-raids by elephants by as much as 80%, but the bees are also helping to pollinate the fields, and farmers are now harvesting valuable "Elephant-Friendly Honey" as an additional product from their land. Since starting her research in 2006, the Beehive Fence HEC mitigation concept has spread rapidly and Beehive Fences are presently up and running in test sites in Kenya, Tanzania, Uganda, Botswana, Mozambique, India and Sri Lanka and has now been incorporated into Kenya's 2012-2021 management strategy for elephant conservation in the country. The Elephants and Bees Project (www.elephantsandbees.com) is lead by Dr Lucy King under the umbrella of the research charity Save the Elephants.

Contact Details:
Dr. Lucy E King
Email: lucy@savetheelephants.org
Website: www.elephantsandbees.com and www.savetheelephants.org
Facebook: https://www.facebook.com/ElephantsandBees

Honey Bee Health and the landscape: Feasts, Famines, and Solutions

Zach Browning

American Beekeeping Federation

70% of the crops we rely on for our human diet and pollinated, mainly by honey bees. Bee decline has amplified our focus on what is required to sustain this critical balance. Modern agriculture systems that rely on bees are very productive in terms of yield per acre, but that efficiency has come at a cost. That cost is plant diversity and accessible clean forage within the farming environment.

Bees need abundant pesticide free forage to sustain healthy populations that are required for pollinating crops. Without good nutrition, from clean abundant forage, bees are weak and more susceptible to many of the stressors known to weaken hives, including pests, disease, and even pesticide poisoning. Hives that are able to access good forage tend to be more healthy and robust and are more likely to survive periods of dearth and the movement to and from different pollinating jobs.

Unfortunately, we are losing suitable honey bee habitat at alarming rates. Pressure from high commodity prices has converted millions of acres of traditional bee pasture into crop production in just the last few years. Furthermore, modern farming practices use herbicide on such a wide scale, that few areas are left that could support any natural forage. Not surprisingly, over the past decade both honey crops and bee health nationwide have suffered significant declines.

If our aim is to improve honey bee health and preserve our pollinators, then we must invest in habitat and sustainable farming practices. Conservation programs have shown promise in the past. Farmers, applicators, and land managers must understand the relationship between bees and the agriculture system. The Honey Bee and Monarch Butterfly Partnership is aligning beekeepers interested in promoting pollinator habitat and cooperating land owners, by incentivizing forage planting.

Using Best Management Practices (BMPs) on the farm (with both herbicide and pesticide) and dedicating a small amount of land, particularly the fringes or less productive areas of the farm, to habitat only makes good sense and can go a long way toward protecting and promoting the pollinators that we require.

Simultaneously enhancing native pollinators and crop yield: conservation in agroecosystems

Laura A. Russo

Penn State University

Pollinator diversity and abundance correlate with yield in many cropping systems. Much research demonstrates that wild pollinators can be as effective, or even more effective, than managed honeybees. I will present case studies showing how wild pollinators provide pollination services in agriculture, and how management actions can be taken to support pollinators. These actions can involve actively planting resource provisioning wildflower strips in agroecosystems or even refraining from removing flowering weeds. First, I show that, in New York apple orchards, wild bees provide more pollination services than honeybees at a majority of surveyed orchards. In locations where bee diversity and abundance were high, orchard managers were able to stop renting honeybee hives without a reduction in yield. Thus, promoting the conservation of pollinators can provide tangible benefits for agriculture. Next, I show two ways in which management actions can be taken to improve the quality of agricultural lands for pollinators. Floral resource provisioning has the potential to increase the conservation value of agroecosystems by supporting wild pollinators. Managers can select species from a range of available options by prioritizing the preferences of the insect visitors to these provisioning species. In addition, I show that patches of a weed species can support wild pollinators in agroecosystems where floral resources are otherwise unavailable. By thinking more broadly about management decisions, land managers could promote biodiversity and ecosystem function in agroecosystems, while simultaneously gaining the benefit of improved pollination services. Thus, the collaborative efforts of agriculture and conservation could be mutually beneficial to both.

Quantifying the impact of species invasions and extinctions on pollination services in a diverse island ecosystem

Anna L. Johnson & **Tia-Lynn Ashman**

Department of Biological Sciences, University of Pittsburgh, Pittsburgh, PA 15260

Pollination networks provide valuable ecological services to both native and managed ecosystems but our understanding of how species invasions and extinctions impact the structure and stability of these complex ecological interaction webs is still developing. We present results from a study tracking the impact of species compositional shifts in dry tropical forests on pollination networks across both spatial and temporal gradients on the island of Hawai'i. We first worked with a uniquely robust herbarium collection to reconstruct centuries-old pollen transport networks, based on pollen deposited on specimen stigmas. Secondly, we observed contemporary pollinator visitation patterns and collected floral stigmas along a spatial invasion gradient in remnant dry forest communities. We compared historic networks to contemporary pollen transport networks to determine how a century of species invasions and habitat loss has altered the structure of plant-plant interactions in this endangered ecosystem. We use this data to discuss the ecological factors which may cause species interactions to change more quickly than species diversity in disturbed ecosystems and highlight the value of incorporating broader spatial and temporal context into studies of pollination systems, especially in the face of rapid global change.

TUESDAY SPEAKERS

SUN | MON | **TUE** | WED

What can pollinators tell us about biodiversity and ecosystem services in real-world landscapes?

Rachael Winfree

Department of Ecology, Evolution, and Natural Resources, Rutgers University, New Brunswick, NJ 08901

Pollinators deliver a critical ecosystem service worldwide. The species providing the service, and the contribution made by each species, are straightforward to measure in the field, at least relative to other kinds of services. For these reasons, pollinators and pollination have become a model system for exploring questions about the relationship between biodiversity and ecosystem services. Hundreds of small-scale experiments have shown that ecosystem processes, including pollination, increase with the number of species providing them. On this basis, the maintenance of ecosystem services has become a cornerstone argument for the preservation of biodiversity globally. However, ecologists actually know rather little about how the biodiversity-function relationship works in real-world ecosystems. In this talk I identify the big questions about biodiversity and ecosystem services that remain to be answered at landscape scales, and how the answers might be systematically different from those already known from smaller scales. I organize my argument around the results of landscape-scale research on pollinators and pollination, as the study system making the single greatest contribution to this field.

Landscape and diet diversity influence bee nutritional health

Adam G. Dolezal [1], Jimena Carrillo-Tripp [2], W. Allen Miller [2], Bryony C. Bonning [3], Amy L. Toth [1,3]

Iowa State University, (1) Department of Ecology, Evolution and Organismal Biology (2) Department of Plant Pathology and Microbiology, and (3) Department of Entomology

Numerous interacting factors are contributing to population and health declines in bee pollinators, including habitat loss, nutritional stress, and diseases. A major goal of my lab's work is to integrate information about bee nutritional physiology and genomics in order to understand how interactions between environmental stressors contribute to bee health. Working in the intensely agricultural Midwest, we have examined the interactions between landscape and floral resource diversity on bee nutritional physiology and response to viral diseases. Thus far, our studies indicate that managed honey bees kept in extremely highly cultivated areas suffer from reduced nutritional health at the critical pre-overwintering period. Field and lab experiments show that nutritional stress, including feeding on low diversity pollen diets, make bees more likely to succumb to viral infection. Interestingly, even when bees have sufficient food (i.e. are not suffering from a lack of calories), a lack of diet diversity and associated micronutrient deficiencies are associated with increased susceptibility to viruses. In a hive setting, interactions between nutritional stress and viral infection may also lead to perturbations in colony division of labor. Ongoing work is expanding to examine nutritional health of wild bees, as well as delving deeper into the underlying mechanisms of these interactions by examining how honey bees respond to nutritional stress and viral infection on the transcriptomic level.

Molecular Studies of Bumble Bee Nutrition

S. Hollis Woodard

University of California, Riverside

Michelle Duennes

University of California, Riverside

Joshua Der

California State University, Fullerton

Shalene Jha

University of Texas at Austin

Unavailability of food resources appears to be a major factor involved in the decline of wild pollinators, and yet we know relatively little about the mechanistic basis of nutrition and health in most pollinator species. Here we report results from a series of experiments examining the influence of diet and nutrition on queen bumble bee (*Bombus impatiens*) physiology and health. We provide evidence that nutrition during early life has persistent effects on physiological and transcriptomic processes in bumble bee queens, which likely have broader impacts on queen health and fitness. We also demonstrate that nutrients can have unique effects on queens, depending on qualitative and quantitative differences in diet as well as the age at which diet treatments are administered. Given that queens are the main reproductive unit in bumble bees, these findings suggest that there are critical nutritional periods for queens that might have compounding effects on bumble bee population dynamics. Further, these findings shed light on strategies for better managing pollinator foraging habitat to improve bumble bee conservation efforts.

Answering the 'what, when, where, why and how' questions for pollinator habitat creation in UK agricultural landscapes

Claire Carvell [1], **Andrew Bourke** [2], **Juliet Osborne** [3], **Seirian Sumner** [4], **Lynn Dicks** [5], **Richard Pywell** [1], **Matthew Heard** [1]

1. NERC Centre for Ecology and Hydrology, Wallingford, UK
2. University of East Anglia, Norwich, UK
3. Environment and Sustainability Institute, University of Exeter, Cornwall, UK
4. University of Bristol, Bristol, UK
5. University of Cambridge, Cambridge, UK

Many of the UK's native bee species and other insect pollinators are thought to be in decline. The implications of these declines for food production and wider biodiversity have led to substantial attention being directed towards research and conservation efforts, including through 'ecological intensification' to re-create lost habitats for pollinators on farmland. This talk will summarise the findings of several research projects aiming to assess the response of pollinators (especially bumblebees) to newly created and restored habitats on UK farmland. We used a combination of intensive field studies, large-scale habitat interventions, molecular genetic techniques and landscape modelling to assess effects at individual, colony and population levels. Projects have investigated what habitats are required; when and how they should be established; how much flower-rich habitat is needed to support populations of the target species; what effects such habitats can have, for example, on bumblebee foraging distances; where in the landscape they should be targeted and finally, why such habitat creation matters for sustaining or increasing crop yields. Close collaboration with agronomists, land managers and policy makers has been critical in enabling the research to directly inform UK Government policies such as the agri-environment schemes.

Impacts of land use in the Northern Great Plains on beekeeper habitat selection and honey bee health

Matthew Smart, **Clint Otto**

USGS Northern Prairie Wildlife Research Center, Jamestown, ND

A large portion of the US commercial pool of honey bee colonies spend the summer in apiaries located across the Northern Great Plains (NGP) region. While historically productive for honey bee forage, this region has relatively recently undergone shifts in land use that may impact the ability of this critical region to support beekeepers and their livestock. Our current research examines the nexus of land use, beekeeper apiary selection, bee-foraged plant species, and honey bee colony health. We ask, 1) Does land use and land use change in the NGP influence beekeeper apiary site selection? 2) What role do specific types of land use play in providing honey bee forage? 3) Which plants do honey bee colonies utilize for pollen in agricultural landscapes across the NGP? and 4) What are the resulting impacts of varying patterns of agricultural land use on the health of honey bee colonies?

Stalking a stem nesting bee: a holistic perspective on wild bee habitat and nutrition

Sandra M. Rehan

Department of Biological Sciences, University of New Hampshire, Durham, NH USA
email: sandra.rehan@unh.edu; website: www.unhbeelab.com

Understanding the nutritional requirements of wild bees is essential for their conservation. Remarkably little is known about wild bee habitat requirements, floral preference, and the nutritional value of pollen resources. Here I provide the first characterization of plant diversity utilized by the mass provisioning, small carpenter bee, *Ceratina calcarata*, an abundant and widespread native pollinator found across eastern North America. Both traditional palynology as well as next generation sequencing approaches reveal concordant results to quantify diet breadth and pollen preference. *Ceratina* are polylectic, generalist foragers. However, like many other bee species considered generalists, floral constancy is observed with two to three pollen species comprising 80-100% of mass provisions. Bees take fewer and shorter foraging trips over the season. Changes in foraging behavior and the nutritional quality of pollen resources available are reflected in the sex and number of offspring provisioned. Both the quality and quantity of mass provisions influence lipid stores, body size and overwintering survival. Lipid stores are vital to overwintering success and transcriptomic assays reveal that lipid metabolism is key to survival. Combined these data provide a holistic perspective on wild bee habitat and nutrition; plant-pollinator networks and pollen-microbial communities are also described for the first time.

Impact of Seasonal Resources on Nutrient Acquisition and Gene Expression in Honey Bees

Gloria DeGrandi-Hoffman, Vanessa Corby-Harris, Stephanie Gage

USDA-ARS, Carl Hayden Bee Research Center, 2000 East Allen Road, Tucson, AZ

Malnutrition is a major cause of colony losses throughout the world. Poor nutrition impedes brood rearing, reduces immune responses to pathogens, and limits colony growth. The population structure and nutritional requirements of honey bee colonies are dynamic. Colonies build in the spring by rearing brood and in the fall prepare for a broodless period of winter confinement. We analyzed the nutrient composition of spring and fall pollens. We fed the pollens to bees reared in colonies during the spring and the fall. The effects of seasonal pollens on spring and fall bees of nursing age with and without inoculation with Nosema were examined by measuring consumption, nutrient acquisition and expression of genes associated with brood rearing and immunity using transcriptomic profiling analysis. Spring and fall pollens differed in concentrations of soluble protein, and particular amino and fatty acids. Bees consumed different amounts of pollen depending upon season when the pollen was collected and the nurse bee was reared. The effects of the nutritional differences in spring and fall pollens on nutrient acquisition and expression of genes relating to brood rearing and immunity in spring and fall bees will be presented.

Integrated Pest and Pollinator Management: Practical Solutions that Farmers Can Live With

Ed Rajotte

Professor, Department of Entomology, Penn State University, University Park, PA 16802

Neelendra Joshi

Assitant Professor, Department of Entomology, University of Arkansas, Fayetteville, AR 72701

David Biddinger

Associate Research Professor, Tree Fruit and Extension Center, Penn State University, Biglerville, PA 17307

Pesticides kill pests and sometimes pollinators. The challenge in agriculture is to preserve pesticide tools for pest management while managing pesticide use to selectively minimize pollinator impacts. The neonicotinoid controversy makes us acutely aware of the arguments involved and the difficulties facing farmers. Polemics for and against neonicotinoids accentuate extremes, but solutions lie in the middle. Pest management scientists face a similar dilemma while developing biocontrol tactics. Biocontrol is maintained through research-based integrated pest management (IPM) approaches where farm profitability is maintained and environmental and human health impacts are minimized. The same approach, now termed Integrated Pest and Pollinator Management (IPPM), can be used to protect pollinators in the same manner. IPPM, like IPM, not only provides management tools, but also accommodates farmers' and land managers' needs as well as the demands of consumers, environmentalists and others through education, regulation, incentives and market demands. The flexibility inherent in IPM approaches allows selective pesticide use based on knowledge of pollinator pesticide toxicity and application methods and timings to minimize impacts. Research and education commitments by government and others can co-opt the vast networks of IPM scientists, university extension, as well as pollination scientists to address the problem.

Unexpected consequences of neonicotinoid seed treatments reveal opportunities for IPM

Margaret R. Douglas and John F. Tooker

Neonicotinoids are the most widely used insecticides worldwide, but their fate in the environment remains unclear, as does their potential to influence non-target species and the roles they play in agroecosystems. Given their use as seed treatments, non-target effects of neonicotinoids on soil-dwelling predators may be especially important.

We investigated the fate of seed-applied neonicotionids in a soil food chain in no-till soybean and corn systems. Using laboratory and field experiments, we tested the influence of neonicotinoid movement on interactions among crops, non-target slug pests, and their arthropod predators. We also performed a meta-analysis of existing research to estimate the effect of neonicotinoid seed treatments on natural enemies more generally.

Slug pests were unaffected by neonicotinoids in the laboratory, but were able to pass the toxins up the food chain, with lethal and sublethal consequences for predators. In the laboratory and field, neonicotinoid residues declined through the food chain but field-collected slugs still contained biologically relevant concentrations of neonicotinoids. In soybean, neonicotinoid seed treatments depressed early season predator activity, with cascading effects on slug activity, crop establishment, and yield. Finally, meta-analysis of existing field research suggests that neonicotinoid seed treatments have a consistent negative effect on insect (but not arachnid) natural enemies, and that this effect is similar to reductions caused by broadcast applications of pyrethroid insecticides.

Our results indicate that predator populations and the control that they provide can benefit from avoiding neonicotinoid-treated seeds. Farming with untreated corn or soybeans can be challenging in the current marketplace because supplies can be limited, but our interactions with farmers in PA are revealing that many are open to farming with untreated seeds and relying more heavily on IPM.

The California Almond Experience with Best Management Practices for Growers and Beekeepers

Gabriele Ludwig
Almond Board of California

California Almonds are the largest user of honey bee pollination services in the United States. With increasing almond acreage, almonds have grown in prominence within the California agriculture community, as well in pollination services demand. A mutually dependent relationship has evolved between almond growers and commercial beekeepers. The Almond Board of California (ABC) has a long history of funding research in honey bee health, with the goal of ensuring that almonds are a good and safe place for honey bees. A review determined that the advice to growers and beekeepers on best management practices (BMPs) needed revamping. Thus, the Almond Board undertook a process of getting agreement between a range of stakeholders on what best management practices and issues to address. Once completed, ABC staff, local beekeepers, and California Department of Pesticide (CDPR) undertook a massive outreach effort to encourage their adoption. Now two years into the process, the impact of voluntary efforts can be assessed, and may provide a template for the State Management Plans (MP3).

Strategies for sustainable management and propagation of the blue orchard bee in tree fruit orchards

Natalie Boyle [1], **Derek Artz** [1], **Gordon Wardell** [2], **Steve Peterson** [3] and **Theresa Pitts-Singer** [1]

1. USDA-ARS, Logan, UT
2. Wonderful Orchards, Bakersfield, CA
3. Private consultant, Visalia, CA

The blue orchard bee (BOB), *Osmia lignaria*, is a native bee that is an excellent pollinator of tree fruit orchards. Due to the annual rising costs of honey bee hive rentals, many orchardists are eager to develop management tools and practices to support BOBs as alternative pollinators. Our research has demonstrated that concurrent use of BOBs with honey bees significantly increases fruit set in almonds. Additionally, about 400 BOBs per acre are capable of efficiently pollinating almonds supplied with half the typical stocking rate of honey bees (one hive per acre). To date, one of the principal challenges in commercializing BOB pollination is ensuring an economically viable supply of these pollinators across years. Annual scarcity of wild-trapped BOBs limits their availability for purchase, and the low success rate of in-orchard propagation limits their use in commercial settings. To establish BOB pollination as a sustainable industry, many considerations of BOB and orchard management can be made. Research shows that, with the adoption of certain management strategies, such as planting floral enhancements, providing access to mud for nest-building, and proper bee emergence timing, sustainable in-orchard BOB propagation is possible.

Integrating Pest and Pollinator Management for Lawns, Ornamental Landscapes, and Golf Courses

Daniel A. Potter, Jonathan Larson [1], Emily Dobbs [2], and Bernadette Mach

Department of Entomology, University of Kentucky, Lexington, KY 40546-0091 USA

1. Current address: University of Nebraska Extension, Omaha, NE
2. Current Address: Dept. of Environmental Studies, Emory University, Atlanta, GA

This talk explores how the "bee issue" is impacting the Green Industry charged with controlling destructive insect pests of lawns, ornamental landscapes, nurseries, and golf courses while also safeguarding pollinators. Case studies are presented which illustrate how the two IPMs can be reconciled through best management practices; e.g., modifying timing of insecticide applications, mowing to remove flowering weeds should lawns be treated for insect pests, or substituting relatively bee-friendly insecticides for more broadly toxic ones. The bee issue also provides opportunities for growers, landscape managers, and small business owners to benefit by marketing bee-friendly goods and services. Programs such as Operation Pollinator for Golf Courses and the Million Pollinator Garden Challenge are examples of how diversifying urban landscapes can help to reconcile commercial and recreational demands with biodiversity conservation. Our research documenting bee assemblages of 70 species of flowering trees and shrubs suggests options for diversifying landscapes with pest-free, desirable, but heretofore under-utilized woody ornamentals, while another project indicates that micro-clover may be a pollinator-friendly alternative to monoculture turf lawns. Polar bears, bald eagles, and other iconic species can be powerful drivers for social change. I suggest the bee issue is a teachable moment for nurturing sociocultural shifts toward more sustainable urban landscapes.

Threat to an ecosystem service: pesticide induced impairment to individual and colony level traits in social bees

Richard Gill [1], Dylan Smith [1], Leonie Gough [1], Thomas Colgan [2], Yannick Wurm [2] & Andres Arce [1]

1. Department of Life Sciences, Imperial College London, Silwood Park, Ascot, UK
2. Department of Organismal Biology, Queen Mary University of London, London, UK

Bee pollination is critical in maintaining diverse wildflower populations and producing high yielding flowering agricultural crops. Protecting this ecosystem service, by understanding the threats to bees, is thus important. The global spread of intensive agriculture across rural landscapes has been associated with reported population declines. A heavily debated question is whether the use of neurotoxic agrochemicals on flowering crops presents a pesticide exposure landscape that can inadvertently harm foraging bees. In social bees, whilst exposure during foraging may only produce sublethal effects, it is important to understand whether impairment may build-up to cause reduced colony development/fitness – yet evidence to support this is still lacking.

I will showcase laboratory and semi-field experiments we have conducted over the past 3-years: presenting how low-level, chronic exposure to systemic insecticides affect key learning and foraging traits in bumblebees, and how this can transcend to colony impacts. Our exposure studies include: i) bridging the gap between lab and field experiments; ii) look at foraging preferences to address the debate concerning hazard versus risk; iii) effect(s) on physiological development and adult behaviour after brood exposure; iv) utilise advances in molecular techniques to reveal selective signatures in wild bumblebee populations associated with intensive agricultural practices.

Managing farms and landscapes for both biological control and pollination services

Heather Grab [1,2], Katja Poveda [1], Bryan Danforth [1] and Greg Loeb [2]

1. Department of Entomology, Cornell University, Ithaca, New York 14853, United States
2. Department of Entomology, New York State Agricultural Experiment Station, Cornell University, Geneva, New York 14456, United States

Insects provide critical ecosystem services; however, the reliability of these services is threatened as agricultural intensification alters the distribution of resources available to support beneficial insects. Recently, much attention has been focused on management strategies, such as wildflower strips, aimed at conserving beneficial insect populations and ecosystem services. However, the effectiveness of these strategies in supporting multiple ecosystem services simultaneously remains poorly understood. Here, we investigate the effects of perennial wildflower strips on the delivery of pollination and biological control services to strawberry across a landscape gradient. We find that management with wildflower strips positively influences both beneficial insect populations and the delivery of ecosystem services, such as pollination and parasitism rates. However, the primary pest of strawberry, *Lygus lineolaris*, was differentially impacted by local and landscape-scale management such that in low agriculture landscapes plots adjacent to wildflower strips had fewer nymphs than control plots; while in high agriculture landscapes, plots with a wildflower strip had greater nymph densities than control plots. The differential effects of local and landscape structure on pests and beneficial insects resulted in differences in strawberry yields across treatments. Our work has important implications for the design of agricultural systems that support multiple ecosystem services simultaneously.

Genetic diversity of restricted wild bumblebees (Bombus) was already low a century ago before the agricultural intensification: a case study in Belgium with historical specimens (1913-1915) with recent ones (2013-2015)

Kevin Maebe [1], Ivan Meeus [1], Sarah Vray [2,3], Thomas Claeys [1], Wouter Dekoninck [4], Jean-Luc Boevé [4], Pierre Rasmont [2], Guy Smagghe [1]

1. Department of Crop Protection, Faculty of Bioscience Engineering, Ghent University, Coupure links 653, 9000, Ghent, Belgium
2. Laboratoire de Zoologie, University of Mons, Place du Parc 20, 7000 Mons, Belgium
3. Department of Geography, University of Namur, Rue de Bruxelles 61, 5000 Namur, Belgium
4. Royal Belgian Institute of Natural Sciences, Vautierstraat 29, 1000 Brussels, Belgium

Since the 1950s, one of the most important pollinators, bumblebees, are declining worldwide. The causes of this phenomenon remain heavily debated. In Belgium, bumblebee populations are under stress with evidence of species declines, similar to trends seen in Europe for agricultural intensified regions. Our hypothesis is that restricted bumblebee species have lower effective population sizes than widespread species and show a decrease in genetic diversity over time due to an increased effect of genetic drift. Here, genetic diversity in recent *versus* historical populations of bumblebee (*Bombus*) species was investigated by selecting four currently restricted and four currently widespread species. Specimens from five locations in Belgium were genotyped at 16 microsatellite loci, comparing historical specimens (1913-1915) with recent ones (2013-2015) (Fig. 1). Results clarified that both historical and recent populations of restricted species showed a significantly lower genetic diversity than found in populations of co-occurring widespread species. Furthermore, populations of restricted bumblebee species have lower effective population sizes. Surprisingly, restricted species showed no major reduction in genetic diversity over time. This shows that the genetic difference between species was already present before the major drivers of bumblebee decline could have acted. These results suggest that the alleged drivers of bumblebee decline are not directly linked with the genetic variation of currently declining bumblebee populations. A future sampling in the entire distribution range of these species will infer if the observed link between low genetic diversity and population distribution on the Belgium scale correlates with species decline on a global scale.

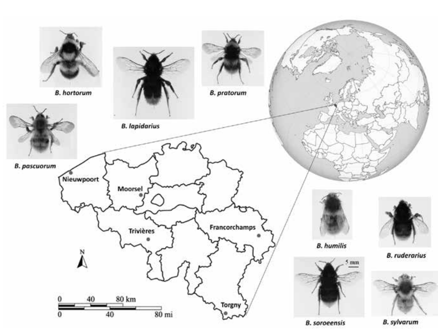


Fig. 1. Overview of the bumblebee species sampled at five locations in Belgium. Specimens for each species were collected at the same five locations in Belgium in 1913-1915 and 2013-2015. Pictures of species are from Rasmont & Pauly (2010).

This project is supported by the Belgian Science Policy (BELSPO; BR/132/A1/BELBEES; Multi-disciplinary assessment of BELgian wild BEE decline to adapt mitigation management policy).

WEDNESDAY SPEAKERS

SUN MON TUE **WED**

Understanding the Relationship Between Genes and Social Behavior: Lessons from the Honey Bee

Gene E. Robinson

Carl R. Woese Institute for Genomic Biology, Department of Entomology, Neuroscience Program
University of Illinois at Urbana-Champaign

The study of genes and social behavior is still a young field. In this lecture, I will discuss some of the first insights to emerge that describe the relationship between them. These include the surprisingly close relationship between brain gene expression and specific behavioral states; social regulation of brain gene expression; control of social behavior by context-dependent rewiring of brain transcriptional regulatory networks; evolutionarily conserved genetic toolkits for social behavior that span insects, fish and mammals; and evolutionarily labile pathways that subserve "me to we" transitions from the regulation of selfish to cooperative behavior.

"Tracking parasites, pathogens, and disease in pollinators: the potential and pitfalls of molecular approaches"

Mark J F Brown

School of Biological Sciences, Royal Holloway University of London, UK

Parasites and disease are one of the major drivers of honey bee declines. However, increasing evidence suggests that they may also have significant impacts on wild bees, particularly bumblebees. Assessing the prevalence and impact of parasites, pathogens and disease in wild pollinators is challenging. Classic parasitological techniques, as pioneered in studies of the evolutionary ecology of bumblebee-parasite interactions, are limited in the range of taxa they can detect, and the sensitivity of such detection. Consequently, the field has rapidly embraced a range of molecular approaches. Here I use case studies from our work on emerging fungal and viral pathogens in bumblebees to highlight what we can learn using such approaches about the prevalence and epidemiological dynamics of parasites and pathogens in wild bees. Our work shows that so-called honey bee viruses infect both honey bees and wild bumblebees, with the potential for spillover and emergence in both directions, depending upon the virus. However, as with all techniques, molecular tools cannot provide a panacea, and I discuss directions for future studies that could drive forward our understanding of the dynamics and impacts of disease in wild bees.

Honey bee viruses, colony health, and antiviral defense

Laura Brutscher [1,2,3], Katie F. Daughenbaugh [1], Ian Cavigli [1], Emma Garcia [1], Madison Martin [1,2], William Glenny [1,2,3], Alex McMenamin [1,2,3], and Michelle Flenniken [1,3]

1. Department of Plant Sciences and Plant Pathology,
2. Department of Microbiology and Immunology,
3. Institute on Ecosystems,

Montana State University, Bozeman MT

Honey bees are important pollinators of plants, including numerous agricultural crops. Since 2006, US beekeepers have experienced high annual honey bee colony losses, which may be attributed to multiple abiotic and biotic factors, including pathogens. However, the relative importance of these factors has not been fully elucidated. To identify the most prevalent pathogens and investigate the relationship between colony health, we assessed pathogen occurrence, prevalence, and abundance in Western US honey bee colonies involved in almond pollination. The most prevalent pathogens were RNA viruses (including BQCV, LSV2, SBV), *N. ceranae*, and trypanosomatids. Our results indicated that pathogen prevalence and abundance were associated with both sampling date and beekeeping operation, prevalence was highest in honey bee samples obtained immediately after almond pollination, and weak colonies had greater mean pathogen prevalence than strong colonies.

To better understand the effects of RNA viruses on bee health at the individual level, we infected bees with a model virus (Sindbis-GFP) in the presence or absence of dsRNA, which is the substrate for sequence-specific RNA interference-mediated antiviral defense, and a trigger of sequence-independent (non-specific) antiviral responses. Transcriptome sequencing identified more than 200 differentially expressed genes, some of which are involved in RNAi, Toll, and JAK-STAT pathways, but the majority of genes were not well characterized. Further investigation of these genes will yield a better understanding of dsRNA on bee physiology and antiviral defense.

"Advancing our understanding of honey bee queen reproduction and potential applications for beekeepers"

Elina L. Niño [1], W. Cameron Jasper [1] and Christina M. Grozinger [2]

1. University of California, Davis, Dept of Entomology and Nematology, 1 Shields Ave., Davis, CA, 95616
2. The Pennsylvania State University, Department of Entomology, University Park, PA, 16802

Revealing factors and molecular mechanisms that regulate reproductive processes provides insights into regulation of insect reproduction which is crucial for breeding advancement of beneficial insects such as honey bees. Our past research suggests an interplay of various factors in causing and maintaining post-mating changes in queens. For example, the act of copulation, seminal fluid components and seminal fluid volume all play a role in triggering and maintaining changes in sexual receptivity, ovary activation, pheromone production, and transcriptional changes in various reproductively-important tissues. Our ongoing research is further elucidating the role of specific seminal fluid and sperm components in regulating specific post-mating changes. Our preliminary data suggest that semen-associated and not sperm-associated proteins are involved in regulating sexual receptivity and possibly pheromone production. Analyses of the effects of semen- versus sperm-associated proteins on transcriptional changes in queen fat bodies and brains are currently underway. Identifying individual proteins or protein complexes that support queen reproduction would potentially allow us to improve upon established breeding protocols necessary for breeding more resilient honey bee stock.

GWAS for marker-assisted selection and studying colony level traits in Honey bees

Amro Zayed

Dept. Biology, York University

Quantifying the genetics of colony level traits is important for understanding the evolution of social behaviour in insects, and for improving the health of managed pollinators using selective breeding. Although genetic cross-based experiments are able to identify broad genomic loci that influence social traits, they rarely lead to the identification of causal genes and mutations. Genome-wide association mapping is a powerful tool for studying the genetics of colony level traits especially in the social Hymenoptera where high recombination rates result in tighter associations between phenotypic traits and causal mutations. Here we use whole-genome sequencing of queens as well as colony genomes to identify mutations associated with social immunity and defensive behavior of honey bee colonies. Using a variety of methods we are able to detect specific mutations that explain differences in colony level traits in honey bees. We discuss how genome wide association mapping can help elucidate the origins of social traits (e.g. do social traits arise from novel genes, or the co-option of conserved tool-kit genes) and how it can be applied to improve the health of honey bee colonies using marker assisted selection.

Effects of Urbanization on Diseases and Immunocompetence of Native Bees

Margarita M. López-Uribe [1,*], **Robert R. Dunn** [2], **Steven D. Frank** [1], **David R. Tarpy** [1]

1. Department of Entomology, North Carolina State University;
2. Department of Applied Ecology, North Carolina State University

*mmlopezu@ncsu.edu

Pathogens and parasites are one of the main forces driving declines in bee populations worldwide. Still, levels of pathogen infection and disease susceptibility of honey bee pathogens in non-*Apis* bee species remain poorly studied. Urbanization is an important driver of environmental change worldwide, and as such it has the potential to dramatically affect insect populations. Evidence on the effect of urbanization on pollinator communities shows mixed positive and negative results, but its direct effects on pollinator health are just beginning to be understood. Here, we characterize the immune function and pathogen prevalence of four protozoan pathogens in four common native eastern North American bee species (*Xylocopa virginica, Colletes thoracicus, Andrena barbara, Nomada imbricata*) across a gradient impervious surface in urban areas around Raleigh, NC. Using qPCR, we estimated pathogen prevalence and intensity of five common bee pathogens: *Crithidia, Nosema, Ascosphaera, and Apicystis*. Immune function was assessed based on enzymatic activity of phenoloxidase and glucose oxidase. Our preliminary results show high prevalence of *Crithidia* spp. and *Nosema* spp. in three of the bee species sampled. We also found decreasing levels of immune function with increasing urbanization in *X. virginica*. Our results provide novel information about (1) new and *Apis*-transmitted pathogen species, and (2) the potential effect of urbanization and climate warming on host-pathogen dynamics and immune systems in native bees.

Pollinator Community Composition Influences Virus Prevalence in Honey Bees and Native Bees

Michelle L. Fearon and Elizabeth A. Tibbetts

Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor

Agricultural intensification has altered the composition of pollinator communities, changing species interactions and the spread of diseases. Three RNA viruses, Deformed Wing Virus (DWV), Sacbrood Virus (SBV), and Black Queen Cell Virus (BQCV), are rapidly spreading among European honey bees (*Apis mellifera*) and native pollinator species within these altered communities. However, the relationship between pollinator community composition and increased virus prevalence has not been analyzed. Disease ecology theory predicts that (1) increased pollinator species richness will *reduce* virus prevalence, and (2) increased total pollinator abundance will *increase* virus prevalence. To test these hypotheses, I collected 1,750 pollinators from six agricultural sites in southeastern Michigan, with varying pollinator community compositions. I used Reverse-Transcription Polymerase Chain Reactions (RT-PCR) to test 550 *Apis mellifera, Bombus impatiens, Peponapis pruinosa*, and *Lasioglossum* spp. for the presence of DWV, BQCV, and SBV. Preliminary results indicate that *Apis mellifera* and *Bombus impatiens* have higher virus prevalence than *Peponapis pruinosa* and *Lasioglossum* spp. I will test the relationship between virus prevalence within each species along independent gradients of pollinator community species richness and total abundance. These results will provide the first analysis of how virus prevalence changes in multiple pollinator species depending on the surrounding community composition.

Engaging Stakeholders in Pollinator Support on Corridors and Utility Lands

Victoria Wojcik, Mary Galea, Laurie Davies Adams, Evan Cole, Kelly Rourke

Pollinator Partnership, 423 Washington Street, 5th floor, San Francisco CA, 94111, vw@pollinator.org

Utility lands are commonly under some form of landscape management to allow for activities such as power and gas transmission to be carried out safely and efficiently. This landscape management can be a direct complement to pollinator conservation if best management practices (BMPs) that benefit pollinators are implemented. Pollinator Partnership has developed an active research and outreach program focusing on generating BMPs for pollinator conservation on corridor landscapes, monitoring and evaluating active conservation programs, and engaging stakeholders throughout outreach and education programs. Two case studies will be presented here – the first is a summary of our collaborative research with Pacific Gas and Electric into understanding the dynamics of right-of-way management in the west, including: baseline pollinator monitoring, IVM research, and community outreach through garden development. The second case study reviews the development and distribution of land manager guides targeting utilities in the Province of Ontario as a model for other regional programs. Targeted efforts to reach specific audiences result in a higher likelihood of actions being adopted.

Engaging stakeholders and using multiple communication strategies to develop effective pollinator outreach programs and tools

Katharina Ullmann, Emily May, Jennifer Hopwood, Mace Vaughan

The Xerces Society for Invertebrate Conservation, 628 NE Broadway Ste 200, Portland OR, 97232

Multiple factors threaten the world's pollinators, including habitat destruction and degradation. In order to prevent future losses and support remaining pollinator communities we need outreach programs that engage stakeholders and provide opportunities for experiential, technical, and social learning. This talk will highlight case studies from two pollinator outreach programs. Researchers and outreach and extension specialists with the Integrated Crop Pollination Project are working with stakeholders and social scientists to develop outreach tools for specialty crop growers. There are multiple avenues through which stakeholders can provide feedback, e.g. via surveys, personal communication, social media, and the project's advisory board. The Project's diverse communication strategies include the use of written documents, videos, demonstration farms and field days, workshops, trade journal articles, and social media. The other case study will highlight the process used to develop the Federal Highway Administration's recently released guidelines: "Pollinators and Roadsides: Best Management Practices for Managers and Decision Makers". This process included engaging stakeholders via interviews and opportunities to review guidelines. Stakeholders provided key insights into the constraints roadside managers work within when managing roadsides. These insights were taken into account when developing the guidelines.

Penn State Master Gardener Pollinator Friendly Garden Certification Program

Connie Schmotzer
Penn State Extension

This outreach program of the Master Gardener program was created in 2011 with 3 goals:

1. Spread awareness of pollinators and their problems.

2. Educate home gardeners about how they can provide safe havens for pollinators. Focus on creating landscapes that can strengthen and increase native pollinator populations.

3. Provide a communication path to the certified gardeners to continue to improve their own landscapes and to help them educate fellow gardeners.

Gardeners start the process of certification by visiting the website at the Center for Pollinator Research. The website itself was created to be educational, offering links to a variety of resources. The 4 steps for certification are: 1. Provide Food 2. Provide shelter 3. Provide water 4. Safeguard pollinator habitat

Applications are reviewed by a committee of Master Gardeners. At least 3 members must sign off on each application. We frequently communicate with applicants, addressing any concerns of the committee.

Twice a year we send a newsletter to the certified gardeners. Each issue features an outstanding garden, exceptional pollinator plants, plants to avoid, and other news and information. We invite them to comment. Many do.

As of April, 2016, there are 568 certified gardens in Pennsylvania.

Conserving Monarch Butterflies through Education, Outreach, Research and Monitoring

Holly L. Holt [1], Wendy Caldwell [1], and Karen S. Oberhauser [1,2]

1. Monarch Joint Venture, University of Minnesota, 2003 Upper Buford Circle, 135 Skok Hall, Saint Paul, MN 55108, United States
2. Department of Fisheries, Wildlife and Conservation Biology, University of Minnesota, 2003 Upper Buford Circle, 135 Skok Hall, Saint Paul, MN 55108, United States

The Monarch Joint Venture (MJV) works in the US with 45 partner organizations to conserve and protect monarch butterfly populations and their migratory phenomena. To achieve conservation goals, the MJV enacts science-based habitat conservation, restoration measures and research and monitoring in conjunction with multiple stakeholders. In support of these activities, the MJV provides educational outreach to diverse audiences including the general public and citizen scientists.

Citizen scientists play a key role in monarch butterfly monitoring. Due to their migratory life history, monarch butterflies are temporally broadly distributed and tracking their population and habitat to meet restoration goals requires the help of citizen scientists. Currently, the MJV is working with the MCSP (Monarch Conservation Science Partnership) to develop an iterative and integrative surveillance program for monitoring monarchs and their habitat across the US landscape using a spatially balanced design. To contribute to this effort, the MJV will work to build citizen science networks, including the coordinators and participants of the major monarch monitoring programs. Because individuals who volunteer for citizen science programs are more likely to participate in a wide variety of conservation actions, these networks will improve the scientific basis of conservation decisions and increase on-the-ground actions.

Decision modeling to support pollinator-based fruit farm management

Eric Lonsdorf [1,2], **Taylor Ricketts** [2], **Insu Koh** [2], **Claire Brittain** [3], **Neal Williams** [3], **Claire Kremen** [4], **Rufus Isaacs** [5]

1. Franklin and Marshall College, P.O. Box 3003, Lancaster, PA 17604
2. Gund Institute for Ecological Economics, University of Vermont, 617 Main Street, Burlington, VT 05405
3. Department of Entomology, 380 Briggs, University of California-Davis, Davis, CA 95616
4. Department of Environmental Science, Policy and Management, 130 Mulford Hall, #3114, University of California-Berkeley, Berkeley, CA 94707
5. Department of Entomology, Michigan State University, 202 CIPS, 578 Wilson Road, East Lansing, MI 48824

Many crops benefit from pollination services of wild and managed bees. There is increasing recognition that a combination of wild and managed bees are needed to ensure stable supply of crop pollination services. However, there is still a need to quantify the costs and benefits of pollination enhancement strategies. We modified a spatially-explicit modeling framework designed to provide insights for farmers interested in integrating wild and managed bee enhancement options into crop pollination management. We address whether the costs of the enhancement strategies outweigh the benefits to crop yield under a range of wild bee habitat qualities. We also incorporate stochasticity in wild bee habitat quality to represent year-to-year variation in precipitation. We find that as the quality of wild bee habitat surrounding a farm declines, year-to-year variation in expected yield increases and the expected crop value declines. The use of managed hives is likely to reduce variation in yield and improve expected value up to a point. Once pollination service is saturated, adding enhancements increases certainty in expected value, but also reduces the expected return. Overall, our framework can be used to provide crop and landscape-specific recommendations that account for costs and benefits of wild and managed bees.

The Maine Bumble Bee Atlas: A Multi-Year Citizen Science Project to Survey Bumble Bee Species in Maine

Kalyn Bickerman-Martens [1], Beth Swartz [2], Ron Butler [3], Frank Drummond [1], and Leif Richardson [4]

1. School of Biology and Ecology, University of Maine
2. Maine Department of Inland Fisheries and Wildlife (MDIFW)
3. Division of Natural Sciences, University of Maine Farmington
4. Gund Institute for Ecological Economics, University of Vermont

There are approximately 250 species of bumble bees (*Bombus* spp.) worldwide, 17 of which have been documented to occur in Maine. Bumble bees are an essential component of pollination for a variety of plants throughout temperate, alpine, and arctic climates in the northern hemisphere. In the late 1990s, biologists began to notice significant declines in some North American bumble bee species. These declines have also occurred in Maine, but a sparse historic record of our bee fauna makes assessment of changes difficult. *The Maine Bumble Bee Atlas* is designed as a multi-year, statewide survey from 2015-2019 of bumble bees using citizen scientists. Over 100 volunteers representing 50 townships and 13 counties were trained and collected more than 4,500 voucher and photo specimens from around Maine in 2015. 13 *Bombus* species, including two in the subgenus *Psithyrus*, were collected. *Bombus ternarius* was the most common (~26.5%) and *Bombus terricola*, a species believed to be in decline, made up ~7.75% of all collections. The results of this survey will contribute data on species richness, relative abundances, geographic distributions, and habitat associations that will be used to inform pollinator conservation agendas.

Brain Buzz: A framework for exploring pollination systems knowledge of undergraduates

Doug Golick

Assistant Professor, Department of Entomology, University of Nebraska-Lincoln

Jenny Dauer

Assistant Professor, School of Natural Resources, University of Nebraska-Lincoln

Louise Lynch

Graduate Assistant, Department of Entomology, University of Nebraska-Lincoln

Erin Ingram

Graduate Student, Department of Entomology, University of Nebraska-Lincoln

We interviewed undergraduates at a large Midwestern public university to determine their pollination systems knowledge understanding. Through semi-structured interviews, we collected 25 hours of oral recordings and visual data on undergraduates' understanding of pollination, pollinators, pollinator health, plant/insect interactions, and pollinator conservation practices. We coded student responses and grouped these into convergent themes. Using these themes, we developed a tiered framework of pollination systems knowledge. In this presentation, we will share the pollination systems knowledge framework and discuss its implications for teaching, evaluation, pollination conservation, and future research.

The Northeast Pollinator Partnership

Maria van Dyke and **Bryan Danforth**

Northeast Pollinator Partnership (www.northeastpollinatorpartnership.com) is an effort to develop a sustainable, cost-effective mechanism for providing advice to apple growers in the northeast about the current status of their pollinator fauna and their pollination needs. Our project links participating apple growers with scientists at Cornell to gather data on wild bee and honey bee abundance data across apple orchards in the Northeast. The project involves substantial outreach to apple growers via monthly blog posts and newsletters. We have developed a data collection app (actually a stand-alone website) that allows project participants, including apple growers, extension professionals, and backyard naturalists to capture bee abundance data based on 5-minute visual surveys taken during bloom. The app automatically captures the date, time of day, and latitude and longitude of each observation. We will present some of the web and video materials for the project as well as the app for data capture. Our project may serve as a model for other "citizen science" projects focused on assessing pollinator abundance in agricultural landscapes using smart-phone data capture.

POSTERS

Note:

Posters are listed alphabetically

by underlined presenter's last name.

African meliponine bees as potential hosts for the small hive beetle, Aethina tumida Murray (Coleoptera: Nitidulidae)

Bridget O. Bobadoye [1,3], **Ayuka T. Fombong** [1,2], **Nkoba Kiatoko** [2], **Raina Suresh** [2], **Baldwyn Torto** [1*]

1. Behavioural and Chemical Ecology Department, International Centre of Insect Physiology and Ecology (icipe), P.O. Box 30772-00100 Nairobi, Kenya;
2. Adaptation to Climate Change and Ecosystem Services (ACCESS) Cluster, International Centre of Insect Physiology and Ecology (icipe), P.O. Box 30772-00100 Nairobi, Kenya;
3. Department of Entomology, College of Biological and Physical Sciences, University of Nairobi (UON) , P.O. Box 30197-00100, Chiromo Campus, Nairobi, Kenya.

*Author for correspondence: E-mail: btorto@icipe.org

Olfaction plays a vital role in host-insect interactions. Previous studies have shown that the small hive beetle Aethina tumida can detect odors of bumble bee colonies suggesting that they can serve as an alternate host to the small hive beetle. In this study, we present evidence from olfactory bioassays and chemical analyses of African meliponine bee's odors to show that they can also serve as potential alternate hosts for the small hive beetle. In dual-choice olfactometric assays using various odors sources from the whole hive matrix and individual components inclusive of pot honey, pot pollen, cerumen (involucrum), propolis (batumen) from six (6) stingless bee species, namely H. gribodoi, Meliponula ferruginea (black) recovered in Kakamega forest of Kenya. The antennally-perceived whole colony odor components for Meliponula ferruginea were investigated using coupled gas chromatography mass spectrometry (GC-MS) and linked GC-electroantennographic detection (EAD). The results revealed that female beetles were more responsive than males and significantly preferred whole colony odors to clean air controls. Chromatographic analysis revealed the presence of esters, acids and terpenes as the main odor components of M. ferruginea detected by the beetle's antenna. This study also further revealed similar semio-chemical profiles involved in host location by the small hive beetle in meliponine bees when compared to its closely related eusocial bees (Honey bees).

Key words: small hive beetle / meliponine bees / odors /potential hosts

RNA Viruses in Vermont's Bumble Bees

Samantha Alger

University of Vermont

RNA viruses, once considered to be specific to European honey bees, are among the suspected threats to native bumble bees. However, little is known about the prevalence, effect, and transmission of these viruses among wild bumble bees. Using a combination of field surveys and experiments I am examining the prevalence and viral loads of RNA viruses in wild bumble bees in Vermont and evidence for pathogen spillover from managed honey bees to wild bumble bee species. In a field survey conducted in 2015, bumble bees collected near managed apiaries had a significantly higher probability of infection with deformed wing virus, black queen cell virus and Israeli acute paralysis virus than those collected at sites with no nearby apiaries. Of the bumble bees infected, those caught near managed apiaries had significantly higher viral loads for deformed wing virus and black queen cell virus than bees collected at sites with no nearby apiaries. Future proposed experiments examining transmission routes could help lessen the risk of disease transmission between bee species.

Identifying conservation opportunities for pollinators in urban areas

Katherine Baldock [1], Mark Goddard [2], Damien Hicks [3], Bill Kunin [2], Nadine Mitschunas [1,4], Helen Morse [1], Lynne Osgathorpe [1], Simon Potts [4], Anna Scott [4], Phillip Staniczenko [5,6], Graham Stone [3], Ian Vaughan [7] & Jane Memmott [1]

1. University of Bristol, UK,
2. University of Leeds, UK,
3. University of Edinburgh, UK,
4. University of Reading, UK,
5. University of Maryland, USA,
6. SESYNC, USA,
7. University of Cardiff, UK.

Urban environments are growing globally and are home to more than half of the world's human population. Pollinators supply a crucial ecological service, and finding ways to improve their lot is a major challenge. Our findings from the first stage of the Urban Pollinators Project suggest urban areas can contain high pollinator abundance and diversity, at least for some insect taxa. In the second stage of the research we mapped and sampled all urban habitats in four UK cities to identify opportunities for pollinator conservation in urban areas. We used our data to answer two questions: 1. Which urban habitats are the best for pollinators? 2. Where are the conservation opportunities for pollinators in urban areas? To answer the first question we compared pollinator communities among nine habitats, including gardens, allotments, cemeteries and parks. To answer the second question we used a novel Bayesian modelling approach incorporating information on pollinator dispersal and behaviour to assess the robustness of plant-pollinator networks in response to increases in habitat area and habitat quality. The project was run in collaboration with conservation practitioners and we report on knowledge exchange activities designed to enhance uptake of pollinator conservation by stakeholders in urban areas.

Pollinator response to local and landscape variables in urban agricultural sites

Ashley Bennett and Sarah Lovell

University of Illinois

Consumer demand for locally grown food is expanding urban agriculture across US cities, offering the opportunity to incorporate diversity into urban landscapes. The goal of this study was to examine how local and landscape variables associated with urban agriculture affect bees. We measured bees using pan traps in 19 urban agricultural sites across the city of Chicago, Illinois. Within each urban farm, we measured flower area, flower diversity, hardscape, vegetable production, and farm management (organic or conventional). At the landscape scale, GIS was used to measure the amount of impervious cover in the 500 m surrounding sites. We used model selection to identify local and landscape variables best explaining bee abundance and diversity. The models best explaining the abundance of small bodied soil and stem nesting bees included the local scale variables flower area and hardscape. In contrast, abundance of large bodied bees was best explained by impervious cover, a landscape variable. We found bee diversity was best explained by the amount of impervious cover and flower area. Our results suggest farm design can positively impact the abundance of small bodied bees, while the amount of impervious cover in the surrounding landscape will be important to conserving bee diversity.

Agroforestry's Potential and Pitfalls to Promote Pollinator Habitat in Agricultural Landscapes

Gary Bentrup [1], **Judy Wu-Smart** [2], **Doug Golick** [2], **Tom Weissling** [2], **Julie A. Peterson** [3]

1. USDA National Agroforestry Center, U.S. Forest Service, Lincoln, NE
2. Department of Entomology, University of Nebraska-Lincoln, Lincoln, NE
3. West Central Research and Extension Center, University of Nebraska-Lincoln, North Platte, NE

Addressing pollinator health includes enhancement of habitat within our massive agricultural landscapes. Additionally, it includes constructing drift barriers for reducing pesticide exposure. One promising approach is agroforestry. Agroforestry is the integration of woody and herbaceous plants into crop and animal farming systems to create productive and healthy agricultural operations and lands. Although put in place to meet other objectives, agroforestry practices (i.e., hedgerows, riparian buffers, alley-cropping) can be managed to include pollinator services. This poster summarizes the scientific literature on the benefits and potential trade-offs of agroforestry practices to support pollinator conservation within temperate regions. Agroforestry offers sources of pollen and nectar, particularly when other sources may be scarce, resin for honey bees to form propolis, as well as stable nesting and larval habitat in these frequently-disturbed landscapes. Research indicates these practices can significantly reduce pesticide drift. However, emerging evidence also suggests nectar and pollen in agroforestry plantings can become contaminated by neonicotinoids through non-target drift. Research, initiated by the authors and others, is examining how these multipurpose plantings can be better designed to strategically combine pollinator habitat and drift barrier functions. Merging current knowledge with developing research is yielding solutions to conserve and expand pollinator populations on agricultural lands.

POSTER 6

The Maryland Native Pollinator Survey: utilizing Citizen Scientists to determine the floral preferences of Maryland's native pollinators

Olivia Bernauer and Dennis vanEngelsdorp

University of Maryland, Department of Entomology

Pollinator gardens have become a popular installment in yards, gardens and parks, providing forage and shelter for the more than 400 species of native bees in Maryland. In order to better serve the pollinators of Maryland, we have launched a citizen science project to determine which plants the native pollinators prefer, creating recommendations of the most beneficial plants for Maryland's local, native pollinators.

In 2015, the pilot study of the Citizen Science Native Bee Monitoring Survey in Maryland was conducted. Three Master Gardener groups were contacted to participate. Participants completed one 75-minute training session where they learned: basic insect anatomy, how to distinguish bees from each other and from similar insects, the types of flowers to observe on, and how to collect and submit data. Volunteers were provided with a comprehensive Monitoring Guide and a smaller Pocket guide for field identification. After completing the training session, volunteers observed plants and reported the native bees they saw throughout the spring, summer and fall.

In total, 156 data sheets were submitted and 10,022 pollinators were observed. The most commonly observed group of bees were the bumble bees (n=3643). Plant species and genera were statistically analyzed for their attractiveness to Maryland's native bees.

Comparing plant traits attractive to two social and one solitary bees and linking plant attractiveness to reproductive success

Austin Bauer [1] and Johanne Brunet [1,2]

1. Department of Entomology, University of Wisconsin-Madison
2. United States Department of Agriculture, Agricultural Research Service

Bees collect nectar and pollen and depend on plants for their nutrition. This study identifies and compares the plant traits that are most attractive to two social bees, the honey bee, Apis mellifera, and the common eastern bumble bee, Bombus impatiens, and one solitary bee, the alfalfa leafcutting bee, Megachile rotundata. It also examines how bee visits impact plant reproductive success. Across the three bee species, plants with more racemes were more attractive. Not only did larger floral displays attract more pollinator visits but smaller floral displays increased the probability of receiving no visits. Flower color influenced attractiveness to bumble bee and honey bee but not to leafcutting bee. Plants with more bee visits produced more seeds than plants with fewer bee visits. All three bee species explained variation in seed set, but visits from bumble bee and ALCB increased seed set at a higher rate than honey bee. Only among-plant visits, not within-plant visits, increased seed set for bumble bee and honey bee. All three pollinator species responded to plant traits that advertised the amount of resources available and more attractive plants had greater reproductive success.

Honey Bee Transcriptional Response to Virus Infection

Laura Brutscher [1,2,3], Katie F. Daughenbaugh [1], and Michelle Flenniken [1,3]

1. Department of Plant Sciences and Plant Pathology,
2. Department of Microbiology and Immunology,
3. Institute on Ecosystems,

Montana State University, Bozeman MT

Honey bees are significant plant pollinators in agricultural and non-agricultural landscapes. Since 2006, annual losses of managed honey bee colonies in parts of North America and Europe have been high (e.g., US 33% loss). Colony losses are influenced by biotic and abiotic factors, including (+) ssRNA virus infections. Honey bees have evolved antiviral defense mechanisms, including RNAi and additional immune pathways. However, their relative roles in antiviral defense are not well understood. To better understand honey bee dsRNA-triggered immune responses, bees were infected with a model virus (Sindbis-GFP) with or without dsRNA. In our experiments, dsRNA, regardless of sequence specificity, reduced virus production. To investigate the mechanisms of dsRNA-mediated immune responses in honey bees, we utilized RNAseq to examine transcriptional responses triggered by virus +/- dsRNA. We identified more than 200 differentially expressed genes in bees coinjected with dsRNA and virus. Virus-infected bees had greater expression of genes involved in RNAi, Toll, and JAK-STAT pathways, but the majority of genes with increased expression are not well characterized. Further investigation of these genes will yield a better understanding of dsRNA on bee physiology and antiviral defense and may lead to identification of evolutionarily conserved sequence-independent dsRNA-mediated immune pathways in other organisms.

Evaluation of the honey bee safety profile of a new systemic insecticide, Sivanto™ (flupyradifurone), under field conditions in Florida

Joshua W. Campbell [1], **Ana R. Cabrera** [2], **Cory Stanley-Stahr** [3], **James D. Ellis** [1]

1. University of Florida, Dept. of Entomology and Nematology, 1881 Natural Area Dr., Gainesville, FL 32611
2. Bayer Crop Science, C1550-11 East Wing, 2 TW Alexander Dr., Research Triangle Park, NC 27709
3. Wildlife International, Progress Park, Alachua, Florida 32615

Flupyradifurone (SivantoTM) is a novel systemic insecticide from the butenolide class developed by Crop Science, a division of Bayer. This insecticide appears to have a favorable safety profile for honey bee hives and it can be applied during pre- and bloom in various crops, including citrus,, except mixed with azole fungicides during the blooming period. We placed honey bee (Apis mellifera L.) colonies adjacent to flowering buckwheat (Fagopyrum esculentum Moench) fields that had been sprayed with SivantoTM or controls (no pesticide sprayed). We conducted four colony condition assessments that estimated adult bees, eggs, capped brood, uncapped brood, food stores, and weights of honey supers and brood chambers prior, during, and after the flowering period. We also analyzed bee-collected pollen and nectar for flupyradifurone residues. Overall, the colony assessments revealed no differences in colony strength for any of our seven variables between control and SivantoTM fields. Residue analysis showed that pollen and nectar gathered by bees on fields treated with SivantoTM contained significantly higher flupyradifurone residues than control fields. Our data suggests that SivantoTM may be a relatively safe pesticide for honey bees.

Sustaining essential biotic Ecosystem Services in North African Drylands? Assessing the effects of anthropogenic environmental changes on bee-plant communities on the Saharan fringe in Tunisia

Hayfe Chamkhi

Dept. of Biodiversity, Evolution and Ecology of Plants (BEE), Fac. of Biology, Hamburg University, Hamburg, Germany, hayfe.c@gmail.com

Bee communities, both wild and managed, are an indispensable element of dryland ecosystems as most dryland plants depend on their pollination services. Despite the growing scientific evidence for worldwide substantial losses of bees, the status of bees in North African drylands and their responses to anthropogenic changes remain largely unexplored. This study takes place at the Bou Hedma Biosphere Reserve on the northern Saharan fringes in central Tunisia. The reserve excludes any kind of livestock grazing since more than 30 years and provides the only significant remnants of an Acacia raddiana savanna still existent in the country. To assess the anthropogenic effect on bee communities and their floral ressources, vegetation structure, species abundance and diversity of flowering plants and bees are being surveyed by comparing sites inside and outside the Biosphere Reserve. Furthermore, the importance of bee pollination for the key species Acacia raddiana is being tested using bee-pollination exclusion treatments on flowering buds of Acacia raddiana. The results will contribute to an understanding of factors affecting bee communities and flowering plants in both protected and unprotected conditions. In turn, this will facilitate the design of appropriate management plans to sustain North-African savanna-vegetation, bee species and their related ecosystem services.

Comparison of Native and Non-native nectar and pollen plant forage by Apis mellifera and indigenous bees in a relatively isolated nectar rich late season location in Zone 6

Lorette and William Cheswick

owners www.cheswick.com/farm

A newly transplanted (end of 2015) bee yard with established hives has been placed in upland acreage with diverse tree through ground cover nectar and pollen sources within .5 miles with clear native and non- native volumes. Flight vector and pollen analysis, year to year, will be used to determine hive use of available forage resources throughout the growing season. The system is protected by a river, light industry, 2 railroad tracks, and over 1000 acres of state wildlife management property. No farming has occurred on the land in 50 years, so invasive pressures and pesticide exposure are minimal for a New Jersey property.

The results will guide long term plant choices and maintenance of the river floodplain as a pollinator sanctuary.

How do drones (Apis mellifera) distinguish days of good and bad weather for mating flights?

John Y. Cho [1] and Thomas D. Seeley [2]

1. School of Life Sciences, Arizona State University, Tempe, AZ, USA.
2. Department of Neurobiology and Behavior, Cornell University, Ithaca, NY, USA.

Male honey bees, or drones, are important colony members, because only they and the queens reproduce the colony's genes. Drones leave the hive to mate at certain times on days when it is sunny and warm enough. We investigated how drones know if the weather conditions are favorable. Our hypotheses were: 1) The workers provide weather information to the drones, 2) Drones share the information, and 3) Drones collect the information by themselves. To test our hypotheses, we first described the departure pattern of drones. We then recorded their daily movement in an observation hive. Finally, we followed individually marked drones to identify possible cues from other bees.

The departures were generally concentrated around mid-afternoon. We rejected hypothesis 1 because possible cues from workers did not increase as departure time approached. We did not find support for hypothesis 2 because there was no noticeable interaction among drones. We found support for hypothesis 3 because the drones moved toward the hive entrance even on days with unfavorable weather conditions. We conclude that drones collect weather information by going to the entrance themselves. This is interesting because we expected the workers to provide weather information, given the drones' importance.

Conserving the buzz: An interdisciplinary, multi-stakeholder approach to pollinator conservation in Ontario, Canada

Rachel Nalepa & Sheila R. Colla

York University, Toronto, Ontario, Canada

Southern Ontario is one of the most critical regions in Canada in terms of wildlife-human conflict. It has one of the highest proportions of species at-risk but also dense human population and agricultural productivity. This project proposes to research whether habitat for at-risk pollinators can be adequately incorporated onto private farmland using methods from natural and social sciences. It seeks to determine whether farmers experience a perceived and/or actual financial benefit from this habitat in the form of increased ecosystem services (e.g. pollination, pest control, water conservation) and willingness of landowners are to support at-risk species without financial benefit. By working with the Nature Conservancy of Canada, we will be working to create long term suitable habitat pollinator management plan using wildlife corridors in areas historically occupied by at-risk pollinator species through community-based management with local landowners.

POSTER 14

Modelling range expansion and landscape-scale ecology of a rapidly colonising pollinator

Liam P. Crowther [1], Nick J. B. Isaac [2], Gary D. Powney [2], David S. Richardson [1], Claire Carvell [2], Andrew F. G. Bourke [1]

1. School of Biological Sciences, University of East Anglia, Norwich Research Park, Norwich, UK.
2. NERC Centre for Ecology and Hydrology, Maclean Building, Wallingford, Oxfordshire, UK.

Globally the ranges of many insect species are changing. Such changes are of particular interest and concern in the case of pollinating insects, given they provide key pollination services. Hence it is important to understand the ecological processes that underlie successful colonisation and range expansion by insect pollinators. Bombus hypnorum, the Tree Bumblebee, was first recorded in the UK near the south coast of England in 2001 and has since colonised most of the UK's land mass, expanding its range by ~650 km over 15 years. In this work, we seek to understand this rapid range expansion using different approaches across spatial scales. At a landscape scale we have used genotyping of individual worker bees at microsatellite loci to assign colony membership and estimate population and spatial processes. At the national (UK) scale we developed a novel dynamic occupancy-detection model using a large dataset of Bombus records in order to estimate dispersal distances and effects of habitat on site colonisation in B. hypnorum. Results of this study will be relevant to both B. hypnorum and colonising insect pollinators in general. Furthermore, our approach extends the use of high-quality, yet unstructured, biological records to understand the dynamics underlying range expansions.

Evaluating the Impact of Roadside Vegetation Management on Native Insect Pollinators

Jaret C. Daniels, Geena Hill, Matt Standridge, and Juan Pablo Gomez Echeverri

Florida Museum of Natural History, University of Florida, Gainesville, FL

Roadsides offer many potential resources for pollinators. In Florida, such rights-of-way run adjacent to or intersect both conservation and agricultural lands, the productivity of which is of significant economic importance. Our study examined how roadway margin mowing frequency affected the diversity, richness and abundance of native insect pollinators and herbaceous flowering plants that provide forage. Three vegetation mowing treatments were implemented: no mowing, mowing every 3 weeks, and mowing every 6 weeks. The mowing treatments were administered by the Florida Department of Transportation along six highways in north-central Florida over a two year period. Repeated treatment blocks were distributed between all sites. Each block consisted of a 600m strip of margin parallel to one side of the road's outer edge. Data in the form of pan trap samples and floral resource counts were gathered from all blocks. We found that mowing treatment had a significant effect on flowering plant richness and abundance, and on the diversity of insect pollinators with overall richness, abundance and diversity of insect pollinators decreasing with mowing intensity. Our results indicate that a slight reduction in regular mowing frequency could provide a significant benefit to the pollinator community, especially if implemented over a larger landscape scale.

POSTER 16

The impact of sub-lethal imidacloprid exposure on bumble bee gut bacterial communities

Conroy, D., Maclean, R., Feinstein, L., Dobrin, S.E.

University of Maine at Presque Isle, Presque Isle, ME

Bumble bees are unique among insect pollinators in their adaptation for colder temperatures as well as having specialized morphology and behaviors which aid in effective pollination of complex flowers (Heinrich, 1976). Because gut microbiomes have been linked to organism health, understanding how stressors affect the bacterial communities of the bee gut may lead to novel treatment routes for at risk colonies. We investigated the effect of an environmental stressor (the pesticide imidacloprid) on bumble bee (Bombus impatiens) gut bacterial community composition. Changes in the gut microbiota of 6 hr, 24 hr, 4 day, and 7 day exposure to imidacloprid were assessed using TRFLP analysis. Feeders containing control or imidacloprid-laced sugar solutions were provided to foragers ad lib. For acute (<24 hr) treatments, bees were individually restrained and manually presented control, low (0.6 ppb), or high (10 ppb) doses of sugar solution. Redundancy analysis was used to assess the effects of pesticide dose (control, low, high) and time of exposure (6 hr - 7 days) on TRFLP community profiles. Preliminary analysis suggests a statistically significant effect of treatment duration (999 permutation ANOVA; $p < 0.01$).

Heinrich, B. 1976. Foraging specializations of individual bumble bees. Ecol. Mon. 46:105-128.

Effects of age and behavioral development on responses to Nosema microsporidia infections in honey bees (Apis mellifera)

Mehmet Ali Döke, Christina M. Grozinger

Department of Entomology, Center for Pollinator Research, Huck Institutes of the Life Sciences, Pennsylvania State University, United States

In honey bees, the colony environment can dramatically impact the individuals' physiology, which in turn can influence the responses to parasites and other stressors. Nosema is a widespread gut parasite of honey bees, and infection with this parasite leads to accelerated behavioral maturation and decreased lifespans. However, most studies evaluating the impacts of Nosema on honey bee workers have used young (1–7 day-old) workers raised in cages. In this study, we evaluated the impacts of Nosema infection on workers reared in colonies and collected as nurses and foragers. In the first experiment, we collected nurses and foragers of unknown age from unmanipulated colonies and evaluated the impacts of Nosema infection. However, nurses and foragers differ in both physiological state and age, and thus observed differences in response could be due to either. Thus, in a second experiment, we uncoupled the age and physiological state by creating single-cohort colonies and sampling both foragers and nurses on days 14 and 40. Overall, our results suggest that colony-reared, older individuals are less sensitive to Nosema infection than younger bees, regardless of behavioral state. This study emphasizes the need to conduct field-relevant studies to fully evaluate the impact of stressors on honey bees.

Wild bees commonly harbor, but are not affected by honey bee viruses

Lead Author/Presenter: Adam G. Dolezal [1]

Co-authors: Stephen D. Hendrix [4], Nicole A. Scavo [1], Mary A. Harris [3], M. Joseph Wheelock [2], Matthew E. O'Neal [2], Amy L. Toth [1,2]

1. Iowa State University, Department of Ecology, Evolution, and Organismal Biology
2. Iowa State University, Department of Entomology
3. Iowa State University, Department of Natural Resource and Ecology Management
4. University of Iowa, Department of Biology

Pathogen spillover from managed to wild bees has sparked concern that emerging diseases could be causing or exacerbating population declines. While some pathogens, like RNA viruses, have been found in pollen and wild bees, the severity of the threat to wild bees is largely unknown. Here, we tested 169 bees for five common honey bee viruses, finding that more than 80% of wild bees harbored at least one, and that virus incidence was associated with honey bee presence. We also quantified virus levels, providing the first widespread assessment of viral load in wild bees. Although virus detection was common, virus levels were minimal compared to healthy honey bee hives. Furthermore, when we experimentally inoculated two different solitary bees (Megachile rotundata and Colletes inaequalis) with a lethal mixture of honey bee viruses, we saw no effect on survival or evidence of viral replication. Overall, there is frequent but low-intensity spillover of RNA viruses into wild bee species, likely caused by direct or indirect interactions with honey bees. However, despite frequent exposure, these viruses appear incapable of causing harmful infections in some solitary bees, suggesting that these viruses currently pose a minimal threat to the health of wild bees.

Wild bee communities in non-crop land cover in the Maine (USA) wild blueberry production landscape

Brianne Du Clos[1], **Cynthia Loftin**[1,2], **and Frank Drummond**[3]

1. Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME
2. USGS Maine Cooperative Fish and Wildlife Research Unit, Orono, ME
3. School of Biology and Ecology, University of Maine, Orono, ME

Wild blueberry (Vaccinium angustifolium) production is heavily dependent on insect pollination to set fruit. Wild bees provide up to 30% of this pollination service. The Maine (USA) wild blueberry production landscape consists of irregularly-shaped crop fields that range widely in size. We lack baseline knowledge on wild bee communities in non-crop cover types, and a consistent source of forage beyond crop bloom is unknown. We surveyed wild bee communities in non-crop land cover, including power line rights-of-way (ROW), throughout the growing season in two blueberry growing regions. Power line ROW are a likely source of bee forage and habitat beyond crop bloom. Landscape complexity and mass-flowering crops both promote wild bee diversity and abundance in semi-natural habitat, and we expect to see these trends in our results. We predict greater bee diversity and abundance in the more complex growing region and more diverse and abundant bee communities in power line ROW near wild blueberry fields than those isolated from wild blueberry fields in both growing regions. Understanding how wild bees use the landscape surrounding Maine wild blueberry will aid crop growers and natural resource managers in decision-making regarding pollination management and inform efforts in wild bee conservation.

Evaluating foraging preferences of bee species for commercial ornamental plant species

Emily Erickson [1], **Harland M. Patch** [1], **Sinclair Adam** [2], **Victoria Wojcik** [3], **Christina M. Grozinger** [1]

1. Department of Entomology, Center for Pollinator Research, Pennsylvania State University
2. Penn State Extension, Pennsylvania State University
3. Pollinator Partnership

One of the major factors underpinning declines in pollinators is poor nutrition due to the reduction in the diversity and abundance of flowering plant species. Here, we seek to evaluate the relative attractiveness of popular ornamental flowering plant species and cultivars to pollinators. We will determine if and how pollinator preferences are shaped by the nutritional quality of the pollen provided by these flowering plants. Based on a survey of the largest wholesale growers in Pennsylvania, we identified the top 20 commercial ornamental plant stocks. We will place these stocks in 2 different field locations and evaluate their attractiveness to honey bees, bumble bees, and native bees. We will then collect pollen samples to evaluate ratios of macronutrients and correlate these with attraction. This study will identify additional species and cultivars of flowering plants that will optimally support pollinator populations. Furthermore, it will allow growers to develop production practices for key plant stocks that reduce the exposure of pollinators to potentially harmful pesticides. This project is collaboration between Penn State, the Pollinator Partnership, American Hort., the American Honey Producers Association, and the American Seed Trade Association, and is supported by funding from the Horticultural Research Institute and USDA-APHIS.

Do honey bees and wild bees respond differently to pollinator friendly landscapes?

Elaine Evans, Matthew Smart, Dan Cariveau, and Marla Spivak

University of Minnesota Department of Entomology

POSTER 21

Pollinator declines have prompted action to create and maintain pollinator friendly habitat, often focused on helping either wild bees or honey bees. Concurrent assessment of honey bee and wild bee success will answer questions about how best to support both groups. Wild bee abundance and species and functional diversity were examined at sites near apiaries examined for honey production and colony survival. We asked whether sites that supported successful honey bee colonies also supported diverse wild bee communities and what landscape factors were associated with success. Annual honey production was positively correlated with wild bee abundance and species diversity. Semi-natural land had a positive impact on both honey bee success and wild bee functional diversity, indicating potential for pollinator friendly habitat that serves both effectively. Semi-natural lands included areas rich in floral resources, such as pastures, as well as areas with potentially high quality nesting habitat, such as Conservation Reserve Program land, grassland, and wooded areas. Wild bees and honey bees were found to have a similar, positive response to pollinator friendly habitat.

POSTER 22

Understanding pathogen dynamics in bee communities

Briana Ezray and Heather Hines

The Pennsylvania State University

Bee populations have sharply declined since 2006, raising global concern due to their importance as crop and native plant pollinators. Multiple pathogens are implicated in driving these declines. Previous research has shown that pathogens ranging from diverse RNA viruses to microsporidian fungi are horizontally transmitted between honey bees (Apis) and native bee pollinators in the field. The life cycles of honey bees and bumble bees (Bombus) differ in that honey bees maintain their colonies year round whereas bumble bees have an annual cycle. Therefore, it is hypothesized that this re-establishment of colonies annually in bumble bees may allow for a purge of pathogens. To determine the seasonal incidence of pathogens, we collected European honey bees (Apis mellifera) and common eastern bumble bees (Bombus impatiens) from a variety of landscapes throughout the season and screened the bees for diverse array of pathogens. Our results shed light on pathogen epidemiology and transmission in bee communities and provide essential information for managing pollinator health.

The Bee Friendly Farming Program

Kelly Rourke, Laurie Davies Adams, Kim Fellows*

Pollinator Partnership, *Pollination Canada

The Bee Friendly Farming (BFF) program works with farmers, beekeepers and landowners to improve the health of honey bees, while fostering awareness and support for native pollinators. Its primary focus is on increasing and enhancing bee forage in the U.S. and Canada. BFF-certified farms, ranches, orchards, or vineyards receive recognition and consumer support. Commercial beekeepers also benefit from bee-friendly plantings on fallow lands, which allow them to avoid trucking bees long distances in search of pasture. BFF is beneficial to farmers, beekeepers, and all of us who enjoy the bounty of insect-pollinated foods, medicines, textiles, other raw materials and other ecosystem services, including climate regulation. Please consider getting to know this program and endorsing it.

POSTER 24

Organosilicone Surfactant Adjuvant and Viral Pathogens Cause Synergistic Mortality in Honey Bee Larvae

Julia Fine [1], Diana Cox-Foster [2], Chris Mullin [1]

1. Pennsylvania State University, Dept. Entomology, ASI 512 University Park, PA 16802
2. USDA-ARS-PWA Pollinating Insect-Biol., Mgmt. Syst. Utah State University, Dept. Biology, UMC5310, Logan, UT 84322

As generalist pollinators, honey bees are highly valued for their pollination services in agricultural settings, and recent declines in managed populations have caused concern. Recent colony losses following almond pollination have been characterized by brood mortality and eventual colony loss weeks later. In this study, we demonstrate that these symptoms can be produced by exposing brood chronically to an organosilicone surfactant adjuvant (OSS) commonly used on almonds and to exogenous viral pathogens, simulating a horizontal transmission event. Using Q-PCR techniques to measure gene expression and viral levels in larvae taken just prior to observed mortality at metamorphosis, we found that exposure to OSS and exogenous virus is associated with heightened viral titers and lower expression of a Toll 7-like-receptor associated with autophagic viral defense. These results demonstrate that organosilicone spray adjuvants that are considered biologically inert are toxic to honey bee larvae, and restrictions and guidelines for OSS use should be considered.

Development of Sivanto® as a Safer Insecticide for Bees

David Fischer, Alexander Nikolakis, and Daniel Schmehl

Bayer CropScience LP, Environmental Safety, 2 T.W. Alexander Drive, Research Triangle Park, NC USA

Sivanto® is a new insecticide for the control of sucking insect pests on a broad range of horticulture and broad-acre crops. Sivanto is the first member of a new chemical class of insecticides, the Butenolides (newly created IRAC subgroup 4D), and is a valuable tool for growers for resistance management and Integrated Pest Management (IPM) programs. Sivanto has shown excellent control of neonicotinoid-resistant aphids and white-flies in U.S. field trials, features flexible application methods and timing, and is compatible with a broad range of beneficial insects and predatory mites. Flupyradifurone is the active ingredient of Sivanto and was inspired by the natural botanical product stemofoline, found in plants of the genus Stemona. One of the reasons flupyra-difurone was selected for development by Bayer is its relatively low toxicity to honey bees. Here, we present results for the studies that were undertaken to elaborate the bee safety profile of Sivanto, including laboratory, semi-field and full-field studies. It is expected that Sivanto will substantially contribute to pollinator sustain-ability while providing growers with a tool they need to be successful based on the comprehensive honey bee hazard and exposure database that has been developed.

POSTER 26

Insect Growth Regulator Impacts on Honey Bee Development

Maryann Frazier, Chris Mullin, Ryan Reynolds, Julia Fine

Penn State University

Honey bee populations in the US and Europe are in decline due to multiple factors. Pesticides are under increasing scrutiny for their potential role in the declining health of pollinators including managed honey bee populations, particularly those used for crop pollination. While neonicotinoid pesticides have received the lion's share of attention and blame, other pesticides classes such as fungicides, IGRs and even formulation ingredients are largely being ignored. In 2014 we assessed the impact of selected spray adjuvants and their formulated materials on 56 honey bee nucleus colonies. The formulated material, Rimon® at 1000 ppm (a.i. novaluran; a chitin synthesis inhibitor) was one of eight treatment groups. Twenty-one days post treatment, 100% of Rimon®-treated colonies had eggs but no additional brood stages while control colonies had the normal complement of eggs, larvae and pupae. In 2015 we repeated the field experiment reducing the Rimon® treatment concentration by 1/5 and conducted lab experiments with similar results. Rimon® is considered safe for honey bees and is recommended for use during bloom on most fruit and vegetable crops. This work provides strong evidence for the need to require larval testing of pesticides as part of the registration process.

Signals of Adaptive Evolution in Populations of Kenyan Honey Bees, Apis mellifera

Zachary L. Fuller [1], Elina L. Nino [2,3], Harland M. Patch [2], Jeffery T. Kerby [1,4], Elliud Muli 5, Maryann Frazier [2], Webb Miller [1], Christina M. Grozinger [2]

1. Department of Biology, Pennsylvania State University, University Park, PA
2. Department of Entomology, Center for Pollinator Research, Pennsylvania State University, University Park, PA
3. Department of Entomology, University of California at Davis, Davis, CA
4. Dickey Center for International Understanding, Dartmouth College, Hanover, NH
5. The International Center of Insect Physiology and Ecology, Nairobi, Kenya

The honey bee, Apis mellifera, provides an ideal system to study the molecular mechanisms underpinning adaptive evolution, the genomic consequences of disease presence and how these forces shape the structure of natural populations. Across Kenya, A. mellifera populations are distributed among a range of diverse ecological habitats, including arid deserts, tropical rainforests, temperate savannahs and remnants of coastal forests. Recently, a number of viruses, parasites and other pathogens associated with population declines in U.S. and European colonies have been detected in Kenya, yet appear to not significantly impact colony fitness. Varroa mites, Nosema microsporidia and common North American viruses are found at apiaries throughout Kenya, however their presence alone is not correlated with reduced colony health. Here, we sequenced the full genomes of 11 individuals collected in 2010 to identify genetic signals of adaptation to a set of diverse environments and the recent introduction of European pathogens. Furthermore, we performed an additional survey of Kenya in 2015 and assayed for the presence common European viruses. We find several genes showing evidence of recent positive selection that have been implicated in immunity and parasite resistance pathways. Additionally, we detect the widespread presence of Blackened Queen Cell Virus (BWCV) across southwest Kenya.

Drought stressed sunflowers: Impacts on pesticide residues in pollen and honey bee health

Andrew Garavito and Dennis vanEngelsdorp.

University of Maryland, College Park- Department of Entomology.

In the summer of 2012, members of the Bee Informed Partnership (BIP) received reports from North Dakota beekeepers that the honey bee colonies placed in the vicinity of seed treated sunflower fields fared dramatically worse than they had in previous years. Noting that the state was in a drought that summer, beekeepers theorized that drought stress led to higher concentrations of seed treatment chemicals being expressed in the pollen and nectar that honey bees collected from the sunflowers. To test this hypothesis we collected pollen from both seed treated and untreated sunflowers grown under three different artificial watering regimens and tested the pollen for the systemic pesticides contained in the seed coats of the treated seeds. We found that with decreased watering came an increase in pesticide residues detected in pollen. To assess the impact of these pesticide levels on honey bee health, cage studies were conducted in which bees were fed one of the experimental sunflower pollens and inoculated with the microsporidian pathogen Nosema ceranae. Using N. cearanae susceptibility as an indicator of honey bee health we found no significant differences between the drought stressed sunflower pollens on honey bee health.

Detection of Lake Sinai viruses (LSV) in North American bumble bees

William R. Glenny[3], **Katie F. Daughenbaugh**[1], **and Michelle L. Flenniken**[1,2]

1. Department of Plant Sciences and Plant Pathology,
2. Institute on Ecosystems,
3. Department of Ecology, Montana State University, Bozeman, MT, USA

Habitat reduction, lack of quality forage, agrochemical exposure, and pathogenic infections are factors implicated in bee decline worldwide. While bees serve as a host for a diversity of pathogens, the majority are small, single-stranded, positive sensed RNA viruses.

Several bee-infecting RNA viruses are detected and transmitted between bee species. To examine the prevalence of bee-viruses in wild bumble bees in the Western United States, we sampled foraging bumble bees during the summer of 2015 and utilized pathogen specific Polymerase Chain Reaction (PCR) to test for several bee viruses. We detected Lake Sinai virus 1 (LSV1) and Lake Sinai virus 2 (LSV2) in multiple samples. This is the first report of LSVs in North American bumble bees. We examined LSV replication in bumble bee hosts using negative strand and quantitative PCR, and sequenced the RNA dependent RNA polymerase (RdRp) and capsid encoding regions of the LSV genome. The genome sequences of LSV1 and LSV2 obtained from bumble bee samples ranged from 85-98% identical to those obtained from honey bee samples. This high level of sequence similarity is suggestive of inter and intra-species transmission, though additional studies are needed to better understand virus transmission, evolution, and pathogenesis in sympatric bee populations.

The response of viral titers in infected honey bee larvae to propolis treatment

Michael Goblirsch and Marla Spivak

University of Minnesota

It is common for honey bees to be infected with multiple viruses. Many of the viruses that infect honey bees are positive-sense single-strand RNA viruses [e.g., acute bee paralysis virus (ABPV) and deformed wing virus (DWV)]. Although these viruses persist mainly as asymptomatic infections, when they interact with other stressors such as Varroa mites, their titers can intensify and lead to an accelerated rate of colony decline. There are no treatments against bee viruses; therefore, it is a priority for the beekeeping community to develop strategies to reduce their impact. One avenue for limiting viral infections may be simply encouraging the behavior of honey bees to collect and line their nest with propolis. Propolis has antimicrobial properties, and has been shown to be effective against the fungus, Ascosphaera apis (i.e., chalkbrood), and the bacterium, Paenibacillus larvae (i.e., American foulbrood). Moreover, propolis has shown activity against human viruses. We infected honey bee larvae in vitro with a mixture of ABPV and DWV. We quantified changes in viral titer and markers of honey bee health and immunity after exposure to propolis using quantitative RT-PCR. Results of our preliminary trials will be discussed, along with plans for future research.

Presence of an invasive bee, Anthidium manicatum, changes the foraging behavior of a native pollinator (Bombus impatiens)

Kelsey K Graham [1], **Victoria Forde-Tuckett** [2], **Isabel Obrien** [1], **Sean Boyden** [1], **Kevin Lindell** [1], **Philip T Starks** [1]

1. Tufts University, Medford, MA;
2. Oakwood University, Huntsville, AL

Anthidium manicatum, the European wool-carder bee, first appeared in North America in the early 1960s. Since arrival, A. manicatum has shown rapid range expansion, and aggressive behavior toward native species. A. manicatum males defend floral territories, using evolved spines to attack intruders. Bumble bees (Bombus, spp.), an important native pollinator, are the most commonly attacked native species. Given concern over A. manicatum in North America, we asked two questions over two field seasons:

Year 1: Are A. manicatum successful in excluding native bumble bees from resources?
Year 2: Will bumble bee response to A. manicatum change with continued exposure?

In both years, we used enclosures containing floral resources, with A. manicatum present in experimental enclosures. Bumble bee hives were installed with tubes allowing access inside the enclosure and the surrounding environment. In year 1, there was a significant decrease in bumble bees in all enclosures with A. manicatum. In year 2, exposure time to A. manicatum was tripled, and again bumble bees showed avoidance behavior, and this effect did not diminish over time.

These findings are concerning as bumble bees are important native pollinators that already face resource limitations. Any additional exclusion from resources could hurt bumble bee conservation efforts.

POSTER 32

Maternal and Environmental Effects on Diapause in Megachile rotundata

Tasha Guatney [1], Theresa Pitts-Singer [2], Karen Kapheim [1], and Diana Cox-Foster [2]

1. Dept of Biology, Utah State University, Logan, Utah 84322
2. USDA ARS Pollinating Insects Research Unit, Utah State University, Logan, Utah 84341

Megachile rotundata, the solitary alfalfa leafcutting bee (ALCB) is managed for alfalfa pollination. Growers desire to sustain overwintering (diapausing) pollinator populations, thus minimizing costs of buying additional bee purchases. In ALCB, some larvae undergo direct development to adulthood without diapause and attempt to reproduce in the year of their birth, albeit they have poor reproductive success. Other progeny enter diapause at the end of larval development and emerge to reproduce the following year. Previous studies indicate that diapause condition is influenced by mother bee and mother nature. Many factors determine diapause condition, and our studies documented influences of provision size, mother bee age, and photoperiod during oviposition. Other factors may include access of newly-emerged, overwintered females to nutritional resources that would be used for reproduction, and size of nesting tunnels (that limits larval provision size). Our experiments will investigate diapause probability in relation to nutrition and nesting tunnel size, and viral infections.

Hear a bee, there a bee: Can acoustic monitoring distinguish between various degrees of bee richness?

Elizabeth A. Hedrick [1,3], **David Heise** [2,3]

1. Department of Life and Physical Sciences, Lincoln University, Jefferson City, Missouri, USA.
2. Department of Computer Science, Technology & Mathematics, Lincoln University, Jefferson City, Missouri, USA.
3. CRoMA (Computational Research on Music & Audio) Team of Interdisciplinary Collaborators (CRoMA-TIC), Lincoln University, Jefferson City, Missouri, USA.

While bee-pollinated crop production increases, significant declines in insect pollinator abundance and diversity have been widely documented in recent years, making non-invasive monitoring methods increasingly important. Acoustic monitoring offers a non-invasive and efficient method for monitoring rare and declining species in situ. Our past experiments demonstrated that acoustic measures of alpine bumble bee abundance via their characteristic flight buzzes closely followed visual observations of abundance, and that buzz abundance was a more robust predictor of local clover fecundity than visual observations. While both bee abundance and diversity contribute to crop success, diversity is often a better predictor of success than abundance for some crops. Our goal is to develop efficient software that can determine buzz abundance and frequency diversity within recordings to test the validity of this monitoring system in estimating bee richness in more diverse communities. Flight buzz frequency varies with bee size, within species, and within caste, making acoustically differentiating species difficult in situ. Accordingly, this study will investigate what range of recorded buzz frequencies correspond to sites with various degrees of bee richness (rather than diversity), and whether buzz abundance and diversity (or other features) could serve as proxies for manually observed bee abundance, richness, and diversity.

Factors Driving Bee Community Dynamics in the Colorado High Plains Region

Adrian L. Carper [1], Collin J. Schwantes [1], Deane Bowers [1], Andrew Norton 2, Mary A. Jamieson [3]

1. 1Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, CO, USA
2. 2Department of Bioagricultural Sciences, Colorado State University, Fort Collins, CO
3. 3Department of Biological Sciences, Oakland University, Rochester, MI

Despite concern over native pollinators, baseline data on wild bee communities is lacking in many regions. To determine how local and landscape factors influence bee community dynamics in High Plains agroecosystems of Colorado, we surveyed wild bees in 12 actively grazed rangelands and 20 Conservation Reserve Program (CRP) grasslands. We estimated floral resources within sites and extracted remotely sensed land-cover data at multiple scales. In addition, we examined wild bee reproduction through the use of trap nests. Overall, CRP plantings supported 30% more bees and 24% more bee species on average than rangelands. Bee community responses to landscape factors were guild specific, depending on body size and the scale of habitat measured. Forb richness was nearly twice as high in rangelands and positively related to bee abundance and richness; however, CRP fields produced 48% more bee nests, and female bees in CRP fields provisioned 35% more cells on average, suggesting that grazing of floral resources in rangelands may limit bee reproduction. This study illustrates the importance of conserving habitat quality and floral resources for sustaining abundant, healthy, and diverse wild pollinator communities in agroecosystems.

A comparison of pesticide-metabolizing cytochrome P450 monooxygenase genes annotated from bee genomes

Reed M. Johnson

Department of Entomology, The Ohio State University, Wooster, OH

Cytochrome P450 monooxygenases (P450s) are a superfamily of enzymes involved in the synthesis and breakdown of signalling compounds as well as detoxification of natural and synthetic xenobiotics. With the sequencing of 10 bee genomes it is clear that all bees across the spectrum of sociality share a reduced complement of P450 genes encoded in their genomes relative to other insects. Bee genomes encode between 43 and 62 P450s compared with 85 P450s in Drosophila melanogaster. Much of the reduced P450 diversity in bees is due to a greatly reduced set of genes categorized in the CYP4 family. Bees have between 4 and 6 CYP4 genes while D. melanogaster has 31. The paucity of CYP4 genes is puzzling as members of this family are known to be involved in chemical communication and wax synthesis in other insects -- functions that would seem to be important for bees as well. The CYP3 family, which includes genes associated with detoxification, shows signs of recent expansion through gene duplication in bees. Bee genomes encode between 28 and 38 CYP3 family genes relative to 37 in D. melanogaster. Differences in P450 genes and gene number may help explain differences in pesticide sensitivity in different bees.

Landscapes for honey bees: Identifying landscape features that promote honey bee health through a citizen science partnership

Tyler O. Jones [1], Eric V. Lonsdorf [2], Sarah McTish [1], Douglas A Miller [3], Maryann Frazier [1], Harland M. Patch [1], Christina M. Grozinger [1]

1. Department of Entomology, Center for Pollinator Research Pennsylvania State University , 501 ASI Bldg. University Park, PA 16802, USA
2. Franklin and Marshall College , P.O. Box 3003, Lancaster, PA 17604, USA
3. Center for Environmental Informatics, Pennsylvania State University 2217 Earth-Engineering Sciences Building University Park, PA 16802, USA

It is becoming increasingly apparent that location can greatly impact survival and productivity of honey bee colonies. However, the landscape features most important for determining honey bee health remain to be determined. We will partner with beekeepers that maintain hives in a variety of landscapes across Pennsylvania and the eastern US to determine how hive health varies with landscape characteristics. Together, we will assess colony health parameters including weight, mite loads, and queen health in the fall, winter, and spring. We will then evaluate how these hive metrics are influenced by the surrounding landscape features including land use and cover, forage quality, climate, and meteorological data obtained from existing databases (e.g. the National Land Cover Database and Community Collaborative Rain, Hail, and Snow Network). Our analysis will help us develop models to determine which features are most associated with bee health to develop recommendations for selecting and managing landscapes to optimize honey bee health. The results of this project will help beekeepers understand which landscape features are critical for honey bee colony health, survival and productivity, and will provide a framework for understanding factors impacting wild pollinator health as well.

Nest Manipulation Protects Developmental Stages of Osmia cornifrons From a Cleptoparasitic Mite Pest

Neelendra K. Joshi [1*] and David J. Biddinger [2]

1. Department of Entomology, University of Arkansas, Fayetteville 17307, AR, USA
2. Department of Entomology, Pennsylvania State University, University Park 16802, PA, USA

Email: * nkjoshi@uark.edu

Considering honeybee population decline in the recent years, conservation and propagation of alternate pollinators, such as Osmia cornifrons, is critical to ensure pollination requirement in many fruit crops. A study was conducted using BinderBoard® nest-box to investigate impact of nest manipulation on O. cornifrons. Nests were manipulated by adding paraffin-coated paper liners, and were compared with nests without paper liners to find out if there were any advantages to O. cornifrons developmental stages by protecting them from parasites. In each nest, we recorded the number of nest cells with the cleptoparasitic mite (Chaetodactylus krombeini), number of cocoons, number of males and females, as well as unconsumed pollen balls. Results of this study showed that the addition of liners in the nests provided protection to developing O. cornifrons from the invasion of C. krombeini mites, as the mean number of nest cells with mites were significantly lower in these nests compared to the nests without liner. Significantly higher numbers of cocoons, both male and female were recorded in the nests with paper liners. These results suggest that using nests with paper liners may accelerate O. cornifrons population establishment and propagation in commercial orchards of rosaceous fruit crops and possibly other agroecosystems.

POSTER 38

Determining Field Realistic Exposure Levels of Systemic Insecticides to Pollinators in Apple Orchards

D. Biddinger [1]*, S. Shugrue [1], N. Joshi [2], E. Rajotte [1], C. Mullin [1], N. Phan [1], J. Fine [1], & J. Belsky [1]

1. Department of Entomology, Pennsylvania State University, University Park, 16802, PA, USA
2. Department of Entomology, University of Arkansas, Fayetteville, 17307, AR, USA

Email: * djb134@psu.edu

Pollinators' exposure to systemic insecticides in apple orchards is primarily through the ingestion of contaminated pollen and nectar from pre-bloom sprays rather than by contact with spray residues. To best understand the levels of these types of insecticides that pollinators are exposed to in the field, we mirrored farmer orchard applications by using the same application equipment and used the same rates of formulated product at the same application timings. Pesticides were applied at varying times before flowers opened. Pesticide levels in the nectar and pollen were directly sampled from fifty apple flowers/tree in each of the replicated treatments by using micropipettes and pollen combs. Samples from each tree were combined by type and pesticide levels were determined using liquid chromatography-mass spectrometry. Residue amounts varied by application timing and the type of sample (pollen or nectar) with levels varying from below a detection limit of 2 ppb to average about 20-40 ppb. Using adult Osmia cornifrons to represent wild pollinators, we fed them the same insecticides at the same levels as determined in the field in sugar water and then assessed mortality out to 7 days.

Pollinator conservation in intensive agricultural landscapes: navigating the conservation-production tradeoff

Melanie Kammerer Allen[1,2], **Adam S. Davis**[3], **David A. Mortensen**[1,2]

1. Intercollege Graduate Degree Program in Ecology, The Pennsylvania State University, University Park, PA 16802 USA
2. Department of Plant Science, The Pennsylvania State University, University Park, PA 16802 USA
3. USDA-ARS, Global Change and Photosynthesis Research Unit, Urbana, IL 61801, USA

In intensive agricultural landscapes like the mid-west USA, agriculture is the dominant land use, but only a very small percentage of cultivated land is pollinator dependent crops. This presents little economic incentive to conserve pollinators. How can we motivate conservation of bees and butterflies in landscapes where they aren't important? In intensive agricultural systems, pollinator conservation must be paired with practices that address the conservation and production goals of agricultural producers. We present proposed work on a sub-field diversification strategy to remove unprofitable sections of crop fields from production and install perennial cover to achieve multiple ecosystem benefits, including pollinator conservation. We hypothesize that this approach can minimize the conservation-production tradeoff and incentivize installation of high quality habitat for bees and butterflies.

POSTER 40

Longitudinal Study on the Effects of Pesticides, Pathogens and Mites on Honey Bee Colony Health

Susan Kegley [1], Rose Radford [1], Geoffrey Marcy [1], Timothy Brown [1], Jeff Anderson [2], Steve Ellis [3], and Darren Cox [4]

1. Pesticide Research Institute,
2. California-Minnesota Honey Farm,
3. Old Mill Honey Farm,
4. Cox Honey

Beekeepers have been experiencing unsustainably high levels of colony loss in the last decade. Factors thought to be associated with the decline of honey bee colony health, include pesticides, pathogens, parasites and poor nutrition. Determining the relative contribution of the different factors is paramount to solving the problem, yet few studies are focused on this outcome. In the PSC-PRI study, the health of 60 colonies was tracked over the course of one year and evaluated as a function of Varroa mite loads, pesticide residue concentrations in pollen, and pathogen levels. Measurements of mites, pesticides and pathogens were made four times during the year, with colony strength assessed more frequently. Preliminary results by pallet (average of 4 hives) show significant inverse correlations of percent change in pallet strength between June and October with exposure to specific fungicides and insect growth regulators. Statistical significance increases when fungicides and IGRs are grouped. Weaker correlations are observed for neonicotinoid insecticides. Mite loads by hive had no significant association with hive survival over the course of the year. Observational data suggest that colony failures are driven by queen and larval failures.

Best Practices for Bee Bioinformatics

Clement Kent, Brock Harpur, Amro Zayed

Dept. of Biology, York University, Toronto Canada

POSTER 41

Social insect genomics is a burgeoning field, and the bioinformatic tools used in it are changing quickly. Tools developed for human and mouse genomes often encounter problems with the honeybee genome, due to its high genetic diversity and wide range of GC content. Our lab has been developing a pipeline capable of aligning and calling variants for thousands of honeybee Illumina sequence sets in a reasonable time frame and with strong quality control. In this talk we cover some of the newer tools we have found useful, and some of the quality issues we encountered and how we solved them. Although we use the Apis mellifera genome for most of our examples, we touch upon how well these tools and practices work with non-Apis bee genomes.

"Impact of miticide treatments on honeybee foraging performances"

Simon Klein [1,2], Peta Vine [1], Célia Bordier [3], Andrew B. Barron [1]

1. Department of Biological Sciences, Macquarie University, NSW, Australia
2. Université Paul Sabatier (UPS), Centre de Recherches sur la Cognition Animale, 31062 Toulouse, France
3. INRA, Institut National de la Recherche Agronomique, UR 406 Abeilles et Environnement, Domaine Saint-Paul, CS 40509, 84914 Avignon, France

Beekeepers frequently use chemicals against the parasite mite Varroa destructor, which accumulate at a low level in the wax and the food stores. The impact of miticides on the foraging behaviour of the adult bees from a treated hive is unknown. Moreover, all the studies conducted so far on this subject, investigated the effect of the miticide on varroa-infected hives, therefore any negative effects of the miticide on bees were confounded with indirect positive effects of the miticide on bees via Varroa knockdown. We conducted our experiments in Australia, which is the last varroa-free country.

We examined how larval exposure to hive treatments with the miticides thymol or tau-fluvalinate affected adult foraging efficiency. We (i) accessed to the foraging activity of the bees via RFID technology and (ii) looked at the ability of the bees to associate a specific colour with electric shocks, via a laboratory visual associative learning essay.

Larval tau-fluvalinate exposure affected the learning speed of the bees, but none of the miticide treatments affect their memory when tested after training. Results from the RFID survey indicate that bee were more susceptible to be lost on their first trip when they have been exposed to miticides.

Ecological economic analysis of blue orchard bees in almond pollination

Insu Koh [1], Eric V. Lonsdorf [1,2], Derek R. Artz [3], Theresa L. Pitts-Singer [3], Taylor H. Ricketts [1,4]

1. Gund Institute of Ecological Economics, University of Vermont, Burlington, VT 05405
2. Biology Department, Frank and Marshall College, Lancaster, PA 17604
3. Pollinating Insects Research Unit, USDA-Agricultural Research Service, Logan, UT 84322
4. Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT 05405

Integrating native managed bees into crop pollination is thought to be a way maintain stable profits in response to increasing costs of maintaining and using European honey bees. However, management analyses are lacking regarding how exactly to manage native bees to maximize net benefits. To provide California almond growers with decision support, we developed a cost-benefit analysis for different management scenarios of the blue orchard bee (BoB). We first parameterized an ecology model that predicts BoB visitation as a function of artificial nest density, and explained 17% of the spatial variance of sampled almond yields within an orchard. Using the ecological model, we determined the net profit resulting from a variety of combinations of released female bees (360 to 480 per acre), nest box density (5 or 10 boxes per acre) and number of artificial nests (tubes) per nest box (25 to 175 per box). We found that because blue orchard bees fly short distances (~80m), a higher density of nest boxes ensures more efficient pollination per released female and results in net profits that are up to $1500 greater than lower densities of nest boxes. Future integration of ecological studies with decision analyses will continue to bear fruit.

POSTER 44

An Overview of Native Bees: Current Threats, Policies, and Implications for Conservation

Kelsey Kopec

Center for Biological Diversity; Portland, Oregon

Bee populations are declining around the world, yet many species remain poorly monitored and understood, making species-level threats and declines difficult to discern. This is especially true of North Americans 4,000 plus species of native bees, the majority of which are solitary ground-nesting bees. 94% of North America's native bees remain un-assessed and data deficient, meaning they have no conservation status, no data on foraging and nesting behavior, or current and historical range. These bees face numerous threats from amongst other things, agriculture intensification and climate change, yet are not adequately accounted for in conservation plans or risk assessments. For example, honey bees are used as a surrogate for all other bees in pesticide risk assessments despite vast differences in behavioral traits and life histories, such as the buffering effect colony structure has against pesticides. Through examining life histories, behavioral traits, and current policies we give an overview of native North American bees with implications for pesticide risk assessments and conservation.

Preliminary results of a pollinator habitat along highway rights-of-way study

Lisa Kuder
PhD student, University of Maryland

Dennis vanEngelsdorp
Assistant Professor, University of Maryland

Intro: Our newly initiated study will compare effects of two cost effective meadow management strategies, Integrated Vegetation Management (IVM) and reduced mowing, on diversity and abundance of plant and pollinator communities. Additionally, we will begin to explore whether road contaminants taint roadside vegetation by quantifying sodium and appropriate heavy metal concentrations in floral resources of adjacent wildflowers.

Methods: IVM and annual mowing were implemented spring 2016 at six different roadside plots in central Maryland, USA. Monthly fixed vegetation quadrats and biweekly pollinator sampling began mid spring and will continue for the entirety of three field seasons. Leaves, nectar and pollen are collected from two different distances from the roadsides and will be assessed for roadside contaminants via Inductively Coupled Plasma – Mass Spectrometry. Bee sampling protocol includes pan traps and hand netting.

Results & conclusion: We hypothesize that 1) plant and pollinator communities will be more diverse and abundant in IVM treated plots compared to reduced mow areas and 2) sodium and heavy metal bioaccumulation in wildflowers will vary significantly among plant families. Data obtained from this study will increase our understanding of roadside ecology and aid land managers in development of mitigation strategies that further efforts to promote pollinator health.

POSTER 46

Effects of Exposure to Seed Treatment Insecticides on Honey Bee (Apis mellifera) Colonies During Corn Planting

Chia-Hua Lin, Douglas B. Sponsler, Rodney T. Richardson, and Reed M. Johnson

Department of Entomology, The Ohio State University – OARDC, Wooster, OH 44691

Corn (Zea mays) seeds planted in the US are commonly coated with the neonicotinoid insecticides clothianidin and thiamethoxam, compounds that exhibit high acute toxicity to honey bees. Since neonicotinoid corn seed treatments became widely used in North America and Europe, many beekeepers have reported observing elevated levels of dead bees outside colonies coincident with corn planting in the vicinity of the affected colonies. Recent studies suggest a possible association between elevated bee mortality and insecticide-laced dust particles emitted by pneumatic corn seed planters. We conducted field studies in the corn-growing area of west Central Ohio to better understand the associations between corn planting, the presence of seed treatment insecticide residues in pollen, and elevated bee mortality. A significant increase in bee mortality was observed at hive entrances during corn planting, coinciding with ubiquitous detection of clothianidin and thiamethoxam in bee-collected pollen during planting. Levels of seed treatment neonicotinoid insecticides in pollen were positively correlated with the area around apiaries devoted to corn cultivation. Insecticidal dust generated during corn planting has a clear negative short-term impact on honey bee colonies in Ohio, but the long-term consequences of exposure remain unclear.

Assessing Woody Ornamental Plants for Urban Bee Conservation

Bernadette Mach, Adam Baker, and Daniel A. Potter

The University of Kentucky

POSTER 47

Public awareness of the threat of habitat loss to urban bee populations has increased interest in planting "bee-friendly" landscape plants. Various publications and websites list plant species for bee conservation, but those lists are rarely backed by research. This study aims to document the bee assemblages associated with over 55 species of flowering woody ornamental plants and to spur demand for horticulturally desirable woody plants that are both bee-friendly and relatively pest-free. Bee assemblages will be compared on native and non-native species, on species that bloom at different times during the growing season, and on species with different floral characteristics. 50 bees from each of five sites per plant species were sampled during peak bloom. Plant bloom periods were recorded, as well as flower type and color. Each plant's relative attractiveness was rated based on two 30-second "snapshot" counts taken immediately before collecting the 50-bee sample. Results so far indicate that 1) different flowering ornamentals attract unique bee assemblages, 2) native and nonnative plants can both support diverse assemblages of bees, and 3) some well-adapted, yet underutilized plant species can be good choices for sustainable bee-friendly landscapes.

POSTER 48

Profiling crop pollinators: life-history traits predict habitat use and crop visitation by Mediterranean wild bees

Yael Mandelik and Gideon Pisanty

Department of Entomology, The Faculty of Agriculture, Food and Environment,
The Hebrew University of Jerusalem

Wild pollinators, bees in particular, may greatly contribute to crop pollination. However, the identity, life history traits and environmental sensitivities of main crop pollinator species have received limited attention. These are crucial for predicting pollination services of different communities and for developing management practices that enhance crop pollinators. We sampled wild bees in three crop systems (almond, confection sunflower and seed watermelon) in an Israeli Mediterranean landscape. Bees were sampled in field/orchard edges and interiors, and in the surrounding semi-natural scrub. Although rich bee communities were found near fields, only small fractions visited crop flowers in substantial numbers. The bee assemblage in fields/orchards and on crop flowers was dominated by ground-nesting bees, which tend to nest within fields. Bees' habitat preferences were determined mainly by nesting guild, whereas crop visitation was determined mainly by sociality. The percentage of semi-natural habitat at 250-2500 m radii had a positive effect on bee diversity in all bee guilds, while at 50-100 m radii, only above-ground nesters were positively affected. In sum, we found that crop- and non-crop pollinators are distinguished by behavioral and morphological traits. Hence, analysis of life-history traits of bee communities can help assess the pollination services they likely provide.

Using exposomic profile signatures as predictors of honey bee hive health

Chloe Wang [1], Malia Wenny [1], Robert L. Broadrup [1], Christopher Mayack [2], Anthony Macherone [3,4]

1. Haverford College, Haverford, PA USA,
2. Swarthmore College, Swarthmore, PA USA,
3. Agilent Technologies, Santa Clara, CA USA,
4. Johns Hopkins School of Medicine, Baltimore, MD USA

Many disease and chemical stressors have been identified in the most recent worldwide decline of honey bees (Apis mellifera) and other pollinators. However, none of these factors have led to a “smoking gun” biomarker or array of biomarkers that predict the current and future health status of a hive, and we have yet to identify how exactly these causative factors lead to reduced hive health and ultimate collapse. To address this need, we implemented the exposomics paradigm using gas chromatography-high resolution time of flight mass spectrometry to characterize chemical profiles of honey bees collected from 29 hives from 7 unique geographical locations and compared this with their health status as indicated by disease load using multiplex semi-quantitative PCR analysis. Principal component and unsupervised hierarchal analysis revealed distinct clusters of healthy and unhealthy collapsed hives, with diseased hives as outliers of these two clusters. Our preliminary findings suggest that we can characterize the health status of a hive based on a chemical signature profile and identify multiple factors that might act synergistically and cause honey bee health decline. A longitudinal study is now needed to confirm which chemical changes will predict colony collapse before it occurs.

Non-Chemical Control of Varroa Mites in Honey Bee Colonies

Meghan E. McConnell & Dennis vanEngelsdorp

Department of Entomology, University of Maryland, College Park, MD, 20742

Varroa mites (Varroa destructor), and associated viruses, are arguably the primary driving force behind much of the high rates of loss suffered by beekeepers in the United States (e.g. Guzmán-Novoa et al., 2010). This problem is confounded by the fact that many chemical treatment options fail to work, as mite populations have become tolerant to them (i.e. Apistan: Lodesani et al., 1995). Additionally, some treatments require specific temperature ranges for effective mite control to be obtained (i.e. formic acid) while others cannot be applied until after honey flows, resulting in treatment delays, often well after Varroa levels surpass economic thresholds (i.e. Apiguard). Therefore an effective chemical-free alternative treatment for Varroa is imperative.

We aim to determine if nightly mechanical disturbance (knocking) of hives reduces Varroa population growth. Preliminary testing demonstrated a significant difference in mite drops during disturbance (ANOVA, $F=4.626$, $df=5$, $p=0.075$), however the significant effect is lost once disturbance is stopped (ANOVA, $F=0.7729$, $df=6$, $p=0.4131$) (preliminary data, unpublished, 2014). What remains unknown is if repeated, regular, long-term disturbance will have a measurable impact on Varroa populations over the course of a production season. Here are the results of season long studies monitoring mite population growth over the production season.

Honey Bee Infecting Lake Sinai Viruses

Katie F. Daughenbaugh, Alexander J. McMenamin, and Michelle L. Flenniken

1. Department of Plant Sciences and Plant Pathology,
2. Institute on Ecosystems,

Montana State University, Bozeman, MT, USA

*corresponding author: michelle.flenniken@montana.edu

The Lake Sinai virus group was discovered in honey bees sampled from commercially managed colonies located near Lake Sinai, South Dakota in 2009. Recent studies of managed honey bee colonies determined that LSV2 was one of the most prevalent and abundant viruses in the Western United States. To investigate the relationship between colony health (i.e., frame count) and pathogen prevalence and abundance, we obtained bee samples and colony health data from commercial beekeepers and assessed pathogen prevalence and abundance by pathogen specific PCR and qPCR, respectively. In a small study, LSV2 abundance was greater in weak colonies as compared to stronger colonies, whereas in a larger study colony health was most associated with sampling date and beekeeping operation. To begin to examine LSV transmission and pathogenesis we performed LSV-specific PCR and qPCR of individual honey bee and Varroa destructor mite samples. Tissue-specific qPCR analysis revealed that LSV1 and LSV2 were more abundant in the honey bee gut and abdomen, as compared to the head and thorax. LSV1 and LSV2 were detected in Varroa mites. Together these results suggest multiple routes of transmission may be important for LSVs. Ongoing studies are aimed at better understanding bee host – LSV interactions from the cellular to the colony level.

POSTER 52

Conservation genomics of the yellow banded bumble bee, Bombus terricola

Kailey Michnal, Amro Zayed, Sheila Colla

York University, 4700 Keele St, Toronto, Ontario

Bumble bees (Bombus spp.) are increasingly becoming the focus of conservation strategies as global reports of bumble bee population decline continue to rise. Factors suspected of contributing to the decline of North American bumble bees include habitat fragmentation, climate change, pathogen spillover, and pesticide use. However, it is very difficult to determine the exact cause of declines for any one population or species, and several contributing factors may be acting at once. Here we try to develop transcriptomic tools to assess and diagnose the health of bumble bee populations using our recently-sequenced and assembled genome of the yellow-banded bumblebee, B. terricola. We plan to carry out a pilot transcriptomic study using RNA-sequencing to compare tissue-specific gene expression profiles from B. terricola samples collected from North American populations. Our aim is to discover differentially expressed genes that are diagnostic of B. terricola population size. Patterns of differential gene expression may highlight physiological or metabolic processes that differ between small and large populations, and may provide insight into the contribution of specific stressors to the decline of this species. This method represents an emerging field of conservation genomics and is expected to enable the development of more effective bumblebee conservation strategies.

Refinement of techniques for monitoring bee health and productivity in commercial orchards of the Upper Midwest

Meghan O. Milbrath, **Rufus Isaacs**

Michigan State University, Department of Entomology

Pollinator health is affected by forage availability and diversity in the landscape. Recent programs have been implemented to improve landscapes for pollinators, especially in concentrated areas of pollination dependent orchard crops like Michigan. We are working to understand the value of this restored and conserved land for commercial honey bees and wild bees, using sites with different proportions of restored land. Hive health and productivity are measured using weight data, visual inspections, and disease testing, and the status of colonies the following spring are monitored to determine survival and performance. We are identifying plant usage by weight (showing nectar flows), identification of collected pollen, and transect surveys for honey bees and wild bees in habitats within the flight range of the apiaries.

This project demonstrates the value and ecosystem services provided by pollinator focused conservation lands, while determining important species to improve seed mixes. By identifying the community of pollinators that are using conservation sites, recording differences in colony health of honey bees at these sites, and establishing a record of the plants that are most widely used by all, we can determine the value of conservation plantings, informing land use decisions to protect pollinator health.

POSTER 54

Conservation Ecology for Pumpkin Pollination and Pollinators

Shelby J. Fleischer [1], R. Carley Miller [1], E. Treanore [1], Dana C Roberts [1], James Strange [2]

1. The Pennsylvania State University, University Park, PA,
2. USDA - ARS, Logan, UT

Pumpkins are dependent on animal pollinators for successful reproduction. In our landscape, wild populations of bumble bees (Bombus impatiens) and squash bees (Peponapis pruinosa) are responsible for deliver the majority of pollination visits to pumpkin, and yield is independent of visitation, which suggests that pumpkin pollination is currently being achieved with wild populations. We aim to better conserve wild populations by integrating studies of population dynamics and nutritional provisioning for B. impatiens. Population dynamics are being captured at the colony level through genetic matching of microsatellite diversity among foragers. Nutritional studies are being conducted by evaluating plant performance and bee visitation on cover crop cocktails in field settings, and with nutritional assays to evaluate effects of pollen from these cover crops on B. impatiens fitness in lab settings. This multi-faceted approach also includes educational programming for growers and Extension Educators.

Examining the Relationship Between Foraging Effort and Pollen Collection in Honey Bees and Bumble Bees

Danny Minahan[1] and Johanne Brunet[1,2]

1. Department of Entomology, University of Wisconsin -Madison, Madison, WI
2. USDA-Agricultural Research Service, Vegetable Crops Unit, Madison, WI

Bees are central place foragers, as such, they have evolved strategies to locate, collect, and return to the nest with enough nectar and pollen to maximize their net energy gain. This strategy requires that the habitat surrounding a hive provide a stable array of resources through time. In this experiment we explore the relationship between foraging effort, as indicated by the number and duration of foraging bouts, and pollen collection for two common bee pollinators, honey bees (Apis mellifera L.) and the common eastern bumble bee (Bombus impatiens) through time. Data were collected from hives of both bee species over multiple periods beginning in late-Spring, and into early-Fall. We used Radio Frequency Identification (RFID) to assay the foraging effort of bees during each observation period. Additionally, we removed pollen pellets from individual foragers as they returned from a foraging bout to assay pollen collection patterns. Preliminary results indicate a stable foraging effort by honey bees across periods when considering all measures. However, bumble bees demonstrate a significant increase in foraging effort during the latter part of the summer. Future research will expand on these results and help inform predictive models of social bee foraging through time in modified habitats.

POSTER 56

Bee Health at eXtension.org, a Bee Line from Scientist to Society

Philip Moore, John Skinner, and Michael Wilson

Department of Entomology and Plant Pathology, The University of Tennessee, Knoxville, USA

Rapid technological advancement in agriculture and communication and the effects of globalization over the last half century has caused tremendous change in beekeeping. Effective apiculture extension not only communicates the discoveries in the lab to personnel in the apiary, but can also accelerate the reverse flow of information to benefit researchers working with practical applications. eXtension.org was born during a turning point in the cooperative extension service, when the internet became the primary means of finding information. Since its inception in 2008, the Bee Health community of practice has grown to include over 100 contributing members involved in University and USDA research and extension; who have contributed nearly 500 pages of content, which receive approximately 150,000 views annually. Integrating this evidence based information with social media had led to over 1,000,000 video views on YouTube. As beekeepers wrestle with annual colony losses exceeding 40 percent and reliable information obscured by the democratization of knowledge, apiculture extension through emerging technologies is more essential than at any time before.

Changing flower resources by pre-dispersal seed predators potentially influence on the native pollinators

Junpeng Mu [1], Yan Chen [1], Qinggui Wu [1], Yulian Yang [1], Ruijun Su [1], Stephen G. Compton [2]

1. Ecological Security and Protection Key Laboratory of Sichuan Province, Mianyang Normal University, China;
2. School of Biology, Faculty of Biological Sciences, University of Leeds, UK

The activities of both pollinators and pre-dispersal seed predators generate selection on floral traits, but how they interact with each other via shared floral resources is unclear. We examined how pre-dispersal seed predators modify nectar quality and quantity and thereby influence pollinator behavior. Working in a Tibetan alpine meadow, we hypothesized that increasing levels of pre-dispersal seed predation by larvae of tephritid flies would reduce nectar quantity and quality in Saussurea nigrescens (Asteraceae), and this would make the flowers less attractive to honey bees, the most frequent floral visitors. Our field experiments showed that floret nectar volumes responded differently to high and low densities of fly larvae, with small increases when one larva was present, but large decreases in nectar volume when two or more larvae were present in a capitulum. Experimental manipulations of fly larvae gave the same results. Carbohydrates stored in the capitula declined progressively with fly density, but nectar concentrations were not affected. Honey bee visitation rates were also unaffected, despite the variation in nectar volumes, so no secondary costs associated with seed predation were detected. Honey bees are introduced to the area, and native pollinators may show a different response.

POSTER 58

Interacting landscape and farm-scale factors predict activity of native crop pollinators

Charlie C. Nicholson [1*], **Insu Koh** [1], **Anna Beauchemin** [2], **Taylor H. Ricketts** [1]

1. The Gund Institute for Ecological Economics and Rubenstein School of Environment and Natural Resources, University of Vermont, 617 Main Street, Burlington, VT 05405, USA
2. USDA Exotic and Invasive Weed Research Unit, 800 Buchanan St. Albany, CA, 94710

*Corresponding author phone: 1-413-320-3448; email: ccnichol@uvm.edu

Agricultural landscapes can harbor substantial biodiversity. Certain management practices, such as organic farming, can positively affect patterns of biodiversity, and it is increasingly recognized that the effectiveness of these farming practices are modified by landscape pattern. It is largely unknown however if these two factors interact to impact the supply of ecosystem services. Here we examine whether landscape composition and configuration moderate the effect of farm management on native bee communities visiting highbush blueberry farms in Vermont. We sampled pollinator populations over three years and quantified the visitation rate of native bees to gauge the pollination service these species provide blueberry growers. We found that Vermont blueberry farms are species rich (86 observed species) and largely dependent on wild pollinators (honeybees make <10% of visits). Both native bee visitation rate and species richness increased with the amount of semi-natural area surrounding farms. Organic farms had significantly more species and experienced higher levels of visitation than conventional farms. Moreover, the effect of farm management was strongest in landscapes with less natural area. Native bee diversity and ecosystem service are strongly influenced by both local management and landscape pattern and management transition considerations should take into account broad scale patterns of landscape composition.

Using Urban Snow Removal Procedures to Generate Brackish Pollinator Meadows

Cali Pfaff

Harvard Graduate School of Design & Design Workshop

The procedures and protocols that make up a city's maintenance regime have profound spatial implications. This project retools and reimagines maintenance as a generative, rather than suppressive, force for at-risk urban ecologies. Through the proposal of networked test sites along the rail corridor in Somerville, Massachusetts, the examination of these practices will aim to expand habitat for pollinator species, while testing the bounds of acceptability for wildness in public landscapes.

Currently, snow removal procedures in Somerville direct drivers to stockpile remnant snow on parking lots. This procedure was predated by the dumping of snow into the Mystic River, which was banned by the EPA due to its creation of hypoxic zones. Unfortunately, the stormwater system still drains into the Mystic, meaning the snowmelt heads to the river. This procedure proposes to use the snow melt and embedded road salt to generate brackish marshes that filter and desalinate the water before it enters the Mystic. Through the leaching of retention pools, salinity levels are lowered to support a palette of purple marsh species that support butterfly populations. Color is used as an indicator of what kind of pollinators the flowers support as well as the maintenance regimes that shaped them.

This abstract is an excerpt from a thesis in Landscape Architecture from the Harvard Graduate School of Design. In 2015, the project won a National Student Honor Award in Research from the American Society of Landscape Architects

Visual preferences and learning mediate bumblebees' pollen foraging behavior

Devon Picklum, Felicity Muth, Anne Leonard

University of Nevada, Reno

Pollen is a nutritionally critical resource for bees, and pollen-rewarding plants are common features of native plant communities and agroecosystems. However, many basic features of bees' pollen foraging routines remain unexplored. In a series of lab-based experiments, we show that bumblebees (Bombus impatiens) display innate color preference for anther colors and learn long-term color-pollen associations based on both anther and corolla traits. To explore whether floral traits have evolved to exploit these visual preferences, we investigated bumblebee foraging behavior in relation to heterantherous flowers. These flowers have two anther types that partition the dual functions of pollen into reproduction (pollinating anthers) or reward (feeding anthers). Anther types in heterantherous flowers often differ in visual features and reward quality. We investigate if plants can use bees' innate anther preference to direct within-flower foraging behaviors in model heterantherous flowers. Taken together, these experiments show that color signals play an important role in foraging for nutritionally complex rewards.

The X-Factor: Population genomics identifies potential candidate locus involved in pigmentation variation of the bumble bee Bombus bifarius

Meaghan L. Pimsler, Jason J. Jackson, and Jeffrey D. Lozier

Department of Biological Sciences, University of Alabama

Bumble bees commonly exhibit extensive color variation throughout their geographic ranges, which often coincides with interspecific convergence in pigmentation patterns in regions of co-occurrence. Identifying the genetic mechanisms that contribute to phenotypic variation in color patterns will help us better understand the evolutionary forces that shape the development and maintenance of phenotypic diversification among and between lineages. Previous work using genomic and transcriptomic data from the North American species Bombus bifarius suggested that the red-banded (eastern) color morph was too genetically distinct from the black-banded (western) and intermediate (central) forms to identify candidate loci underlying the major red-black pigmentation dimorphism. Here we reanalyze RNAseq data, focusing on differentiation between the closely related black-banded and intermediate forms. Analysis of 17,450 synonymous and non-synonymous SNPs identified a group of 13 SNPs in a single gene which exhibited unusually high Fst and Tajima's D values compared with the rest of the genome. Levels of divergence at four SNPs were confirmed through Sanger sequencing of 57 individuals from sampling localities beyond the original study. Homologues of this gene play a role in pigmentation in other insects, and therefore this represents a valuable starting point to investigate the genetic basis of bumble bee pigment variation.

POSTER 62

Alternative Routes: Exploring New Avenues for Pesticide Encounters by Solitary Bees

Theresa L. Pitts-Singer [1] **and Andi M. Kopit** [2]

1. USDA ARS Pollinating Insects Research Unit, Logan, Utah
2. Biology Department, Utah State University, Logan, Utah

Because of differences in foraging preferences, nesting behaviors, flight ranges, and seasonality, certain solitary bees may experience greater risks of pesticide encounters than others. Furthermore, the physical and chemical characteristics of pesticides can increase the likelihood of contamination of bees, their nests, and brood provisions. Some examples follow. Translaminar activity of contact pesticides or systematic application of others may contaminate leaf tissue that can enter a nest if the bee uses cut or masticated leaf pieces as cell linings. Depending on solubility properties, crop pesticides applied for all pests throughout the year may be present as the active ingredient, residue or metabolites in soil during bloom, when solitary bees are present. Contaminated soil may be gathered by bees that use mud for nest partitions, exposing females directly to pesticides or providing a means for pesticide to leach from the partition into pollen-nectar provisions fed upon by larvae. Also, plants may uptake pesticides from contaminated soil where they may be later found in the pollen and nectar gathered by bees. Soil, pollen, nectar, and provision samples were collected during bloom under normal conditions and during experiments to investigate proposed exposure routes. Other routes of pesticide exposure are also addressed and discussed.

Addressing the threat posed by Africanized honey bees to south Florida agriculture

R. N. Raid [1], D. Moreira [1], A. Abbate [2], and W. H. Kern [2]

1. University of Florida, IFAS, Everglades Research and Education Center, Belle Glade, FL 33430
2. University of Florida, IFAS, Ft. Lauderdale Research and Educ. Center, Ft. Lauderdale, FL

Africanized honey bees (Apis mellifera scutellata) (AHB) have been observed in Florida since 2001, when first sighted near the port of Tampa. Since that time, they have become firmly ensconced in both urban and agricultural settings south of the I-4 corridor. Africanized honey bees exhibit a more defensive behavior and swarm 4 to 8 times more frequently than Apis mellifera, the common European honey bee used for commercial pollination and honey production. For this reason, Africanized honey bees pose a serious threat to agricultural workers, livestock, and wildlife that may accidently disturb their cryptic hives. These may include holes in the ground, building partitions, old tires, shipping pallets, culverts, or even equipment such as tractors and harvesters. A special safety program is currently being formulated to educate growers and their crews about AHB behavior and the risks they pose. The program is tripartite: 1) awareness and recognition of potential AHB nesting sites, 2) how to react if an AHB hive is accidently disturbed, and 3) how to mitigate or eliminate the threat once an AHB nest is discovered. With 100% of area producers surveyed reporting problems with AHB, it is hoped that this program will reduce or eliminate potential injuries, or even deaths.

Insecticide impacts on bees: from colony founding to pollination services

Nigel E. Raine [1,2], Gemma L. Baron [2], Mark J. F. Brown [2], Dara A. Stanley [2,4]

1. School of Environmental Sciences, University of Guelph, Guelph, Ontario, N1G 2W1, Canada
2. School of Biological Sciences, Royal Holloway University of London, Egham, Surrey, TW20 0EX, UK
3. Department of Life Sciences, Imperial College London, Silwood Park, Ascot, Berkshire, SW7 2AZ, UK
4. Botany and Plant Science, School of Natural Sciences and Ryan Institute, National University of Ireland, Galway, Ireland

Bees are essential pollinators of many crops and wild plants. Whilst pesticides are suggested as one possible factor driving bee declines, a key question is to what extent field-realistic exposure might have significant (sublethal) impacts on individual behaviour, colony foundation and success, and ecosystem service provision. A number of recent studies on the impacts of neonicotinoid insecticide exposure on bumblebees have to started to bridge key gaps in our understanding by linking environmentally realistic results from laboratory to field scale, and also impacts on critical life history transitions – such as between solitary queen and social colony. Field-realistic levels of neonicotinoid exposure can result in a range of individual impacts, including reduced founding success of queens in spring, and impaired cognitive function and pollen collecting efficiency in workers. These sublethal impacts on individual bees can have knock-on effects for colonies in terms of their early success, forager recruitment, worker losses and overall growth and reproduction. Furthermore, the crop pollination services provided by these bees can also be adversely affected following field-realistic insecticide exposure. Taken together these effects could have widespread implications for the stability of wild pollinator populations, sustainable production of many pollinator limited crops, and maintaining wild plant biodiversity.

POSTER 65

Honey Bee Parasitic Mite (Varroa destructor) Feeds On Fat Body Rather Than Just Hemolymph

S. Ramsey [1], **D. vanEngelsdorp** [2]

1. 4146 Plant Science Bldg, University of Maryland, College Park, MD 20742, sramsey@umd.edu
2. 3158 Plant Sciences Bldg, College Park, MD 20742-4454, dvane@umd.edu

Varroa destructor is reportedly the primary driver of the trend of heightened colony losses on a nearly global scale. Successful initiatives to manage Varroa require accurate knowledge of its host-parasite relationship with Apis mellifera. However, very little, if any, experimental data is available to verify the heretofore uncontested claim that Varroa feed solely on the hemolymph of their host. Varroa phylogeny, morphology, and the effects of feeding on the host suggest that this mite feeds on host tissue other than hemolymph. We conducted studies to assess what other tissues could compose the diet of Varroa. Bees were collected from Varroa infested colonies and the placement of apparently feeding mites on each bee was recorded. These mites only fed in areas where their mouthparts were buried in the fat body ((11, N=104)=741.3077) suggesting that this tissue could compose a significant portion of the mite's diet. Hemolymph and fat body in live bees were then stained with fluorescent dyes and mites allowed to feed ad libitum. Resulting data shows an abundance of fat in Varroa's diet. Subsequent assays measuring survivorship on diets composed of hemolymph, fat body, or a combination both suggest that fat body is the primary constituent of Varroa's diet.

POSTER 66

Mycorrhizal fungi affect pollination mutualisms between bees and crop plants

Leif L. Richardson [1,2], **Samantha Alger** [3], **Alison K. Brody** [3], **and Taylor H. Ricketts** [1,2]

1. Gund Institute for Ecological Economics, University of Vermont, Burlington VT USA
2. Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington VT USA
3. Department of Biology, University of Vermont, Burlington VT USA

Nearly 90% of flowering plants participate in pollination mutualisms, interactions which may be structured by floral traits, such as corolla morphology, nectar chemistry, and pollen production. Many plants associate with mycorrhizal fungi (MF) that may alter aboveground trait expression, yet little is known of how trait-mediated indirect effects affect plants and pollinators. Emergent properties of such multispecies mutualisms could have profound consequences for agriculture, where the majority of crops benefit from pollination by wild insects, especially bees. In manipulative field and laboratory experiments, we measured effects of MF on floral traits of highbush blueberry (Vaccinium corymbosum), then asked how differential trait expression affects outcomes of interactions for both blueberry and wild, queen-caste bumble bees (Bombus species), their principal pollinators. We found that plants inoculated with MF had larger flowers, increased pollinator rewards, and increased fruit set, but these effects varied by cultivar. Predicting that MF would affect nectar and pollen chemistry, we demonstrated that consumption of blueberry floral phenolic compounds increased bumblebee reproductive success and survival. We show that mycorrhizal fungi can alter interactions between plants and their pollinators, and conclude that managing belowground mutualisms could benefit farmers by stabilizing the ecosystem service of pollination and increasing crop yields.

Social cues and diet restriction act through similar neural mechanisms to affect aggression in the honey bee

Clare C. Rittschof, Christina M. Grozinger, Gene E. Robinson
University of Kentucky, Pennsylvania State University, University of Illinois

Honey bees exposed to aggression-inducing social cues undergo a shift in brain energy metabolism that causes an enhanced response to future threats. In many organisms, diet restriction also causes changes in brain energy metabolism, which are largely the opposite of those observed in the aggressive honey bee brain. We hypothesized that high-level diet restriction would cause decreased aggression in the honey bee. Contrary to our predictions however, we found that long-term diet restriction caused increased aggression. Short-term diet restriction had no effect on aggression, suggesting the effects of diet are distinct from acute changes in hunger state. General activity, however, increased predominantly in response to short-term diet restriction. Social cues and diet restriction may act through similar mechanisms to affect aggressive behavior, however in the honey bee, diet restriction may induce a brain metabolic state that is the opposite of that observed in other organisms. This could reflect an adaptation to a carbohydrate rich nectar diet; honey bees may differ in the way they metabolize stored fats, or in terms of mitochondrial fuel use. In future studies we will evaluate these possibilities through feeding experiments and measures of brain mitochondrial function in response to different metabolic precursors.

POSTER 68

Woodland Bee Diversity in the Mid-Atlantic: A Citizen Science Survey

Grace Savoy-Burke

University of Delaware (gsburke@udel.edu)

Dr. Deborah Delaney

University of Delaware (dadelane@udel.edu)

Sam Droege

M.S., USGS (droege@usgs.gov)

Declines in honeybees, while partially due to commercial and agricultural practices, are also attributed to human impacts on the natural environment that potentially influence wild bee populations as well. Bumble bees appear to be responding to some of these anthropogenic forces, and declines have been documented in several North American species. However, for the thousands of other wild bees pollinating native ecosystems and cultivated plants, we have very little information on their population sizes and distributions. As a result, we lack a clear understanding of their population status and how they respond to human disturbance. The assemblage of bees inhabiting forest habitats have been particularly overlooked in survey efforts. Many members of these communities engage in specialized relationships with native hosts plants and thus may be particularly sensitive to habitat destruction and climate change. By engaging a team of citizen scientists, we surveyed wild bees in woodlots across the Mid-Atlantic region with the goal of establishing a baseline database and methodology to inform future monitoring. By surveying a variety of forest types on a regional scale, we are also able to reveal patterns in forest bee distributions across the landscape and gain a better understanding of the bee communities utilizing different forest habitats.

Are sand mines an underestimated habitat for wild bee communities?

Nicola Seitz [1,2], Sara D. Leohnardt [1] & Dennis vanEngelsdorp [2]

1. University of Würzburg, Department of Animal Ecology and Tropical Biology, Biocenter - Am Hubland, 97074 Würzburg, Germany
2. University of Maryland, Department of Entomology, 4291 Fieldhouse Dr., College Park, MD 20742, USA

Sand mines may present valuable habitat to wild bee communities, potentially contributing to conserving native pollinators. Due to our demand for concrete we encounter sand mines at many places around the world. Once soil extraction has been terminated, the fields often remain as open landscapes with grass to shrub vegetation and many patches of bare soil.

In a newly initiated study, we investigate whether these areas can harbor wild bees despite being severely disturbed. Bee communities are monitored biweekly at three sand mines in Maryland, USA, throughout the entire blooming period of 2016 using pan traps placed along transects in the sand mines and along roads outside of mines for 24 hours.

We expect that sand mines host more bees and a greater diversity of species than roadsides, indicating that disturbed sand mines may be an important habitat for wild bees.

Comparing bee communities between apple orchards and managed pollinator habitat

Sarah Shugrue [1], Ed Rajotte [2], Neelandra Joshi [3], Tim Leslie [4], Melanie Kammerer [5], Dave Biddinger [1]

1. Fruit Research & Extension Center, Entomology, Pennsylvania State University, 290 University Dr, Biglerville, PA 17307
2. Department of Entomology, 501 ASI Bldg., Pennsylvania State University, University Park, PA 16802
3. Correspondinag author, e-mail: nkj105@psu.edu.
4. Department of Biology, Long Island University, 1 University Plaza, Brooklyn, NY 11201
5. Department of Plant Science, Pennsylvania State University, University Park, PA 16802

Recognizing the importance of all pollinators and the threat of reduced floral resource and habitat, the National Strategy to Promote the Health of Honey Bees and Other Pollinators has addressed pollinator habitat acreage as one of its three main goals, aiming to restore or enhance 7 million acres or land for pollinators by 2020. Pollination (and subsequently crop yields) is higher in areas located closer to natural or semi-natural habitats. Because of this, many researchers are encouraging the creation of flower-rich habitats as hedgerows, field borders, or cover crops to increase bee populations and crop pollination. However, it is still unclear whether these pollinator habitats actually increase the population of pollinators required for crop production. In this study we examine the bee communities found in managed floral resource strips, and how they compare to the bee communities of Pennsylvania apple orchards. We determined that there are significant differences between the bee communities in the orchards and the pollinator strips, but encourage further research on the development of hedgerow pollinator habitat, rather than floral provisioning strips within the orchards.

Pollination ecology of endemic plants of the Channel Islands

C. Sheena Sidhu [1,3] **and Erin E. Wilson Rankin** [2]

1. Postdoctoral Scholar, Department of Entomology, University of California- Riverside, 900 University Ave, Riverside, California 92521. csidhu@alumni.ucsd.edu

2. Assistant Professor, Department of Entomology, University of California- Riverside, 900 University Ave, Riverside, California 92521. erin.rankin@ucr.edu

3. Current address: Research Associate, University of California Cooperative Extension. San Mateo & San Francisco Counties. 1500 Purissima Creek Road, Half Moon Bay, California 94019. cssidhu@ucanr.edu

The Channel Islands, located off the coast of southern California, are home to more than 90 endemic plants. Despite intense historic botanical study across the archipelago, relatively little is known about the pollination ecology of the rarest plants. In 2015, we conducted a series of insect surveys, greenhouse manipulations, and field observations to investigate plant-pollinator interactions and pollination ecology on San Clemente Island, one of the least accessible Channel Islands. Here we share our results related to the pollination ecology of Sibara filifolia (Santa Cruz Island rockcress) and Castilleja grisea (San Clemente Island Indian paintbrush). We found that insect-mediated pollination would benefit S. filifolia, but such services may be in limited due to a phenological mismatch with pollinators. We also found that C. grisea pollination is especially sensitive to the diversity and composition of the surrounding plant community; higher species richness, abundance, and pollinator activity was observed in areas of high plant diversity relative to areas of low plant diversity. This may have contributed in part to responsiveness of this threatened plant to recent botanical restoration efforts on the island. In addition, we report the result of an island-wide pollinator and nesting habitat survey, and describe two potentially new endemic bee species.

POSTER 72

Spatial and taxonomic patterns of honey bee foraging along an urban-rural gradient

Douglas B. Sponsler [1], **Rodney T. Richardson** [1], **Emma G. Matcham** [2], **Chia-Hua Lin** [1], **Reed M. Johnson** [1]

1. The Ohio State University, Department of Entomology
2. The Ohio State University, School of Environment and Natural Resources

Depauperation of foraging habitat has been identified as a central driver of pollinator decline due to the constitutive relationship between nutrition and all other aspects of individual and colony-level health. The main causes of foraging habitat alteration are agricultural and urban development, which create extreme but divergent departures from natural landscapes. Understanding how these two processes interact with the foraging biology and nutrition of pollinators will be key to achieving pollinator conservation through the preservation and enhancement of foraging habitat. For two consecutive years, we sampled pollen from honey bee colonies arranged along an urban-rural gradient in central Ohio, USA. We simultaneously recorded dance behavior from observation hives located at the border of a residential neighborhood and rural farmland, creating an urban-rural choice test assayed by the spatial information of the dance language. Preliminary analysis reveals that while rural colonies foraged almost exclusively on mass-flowering clover and goldenrod, urban colonies collected a high diversity of pollens. We interpret this as a response not to superior urban floral diversity but rather to the rich availability of mass-flowering resources in agricultural landscapes. We will further elucidate this pattern by DNA-metabarcoding of all pollen samples and dance mapping at the urban-rural border site.

Revitalizing urban vacant land for pollinator communities

MaLisa Spring and Mary Gardiner

The Ohio State University

Urban vacant land can offer important habitat for pollinators. Cleveland, Ohio, USA maintains over 1,400 hectares of vacant land. Our goal is to determine how management strategies influence foraging patterns within urban vacant lot greenspaces.

We examined pollinator foraging within five vacant lot treatments: mown and unmown vacant lots with existing vegetation, a low growing flowering lawn mix, and low (4 forbs) and high (16 forbs) diversity pocket prairies. These sites were located in 8 inner-city neighborhoods of Cleveland, Ohio, with each neighborhood containing one site of each habitat type. Sampling occurred once a month in July, August, and September of 2015. Floral visitors were collected with bee vacuums during timed floral surveys. To compare the communities, the floral visitation information was used to make interaction networks with Bipartite in R. A total of 2053 plant visitors greater than 3 mm were collected in 2015 in 72 different arthropod families including 957 bees and 251 hoverflies.

Sites were in early establishment in 2015. Thus, floral resources were similar between habitat types, with most floral abundance coming from "weedy" flora. We expect to see a larger difference in the pollinator communities in the subsequent years once the habitats more fully establish.

POSTER 74

Expert-based Best Management Practices for U.S. beekeepers

Steinhauer, N.A. [1], **Rennich, K.** [1], **Wilson, M.E.** [2] **& D. vanEngelsdorp** [1]
for the Bee Informed Partnership

1. Department of Entomology, University of Maryland, College Park, MD 20742 USA
2. Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37996 USA

*Corresponding author: Email: nsteinha@umd.edu

A survey of honey bee (Apis mellifera) mortalities in the US over the past 9 years revealed an average of one in three colony dying over the winter. More recently, a surprisingly high level of summer loss was recorded (Steinhauer et al., 2014 J.Apic.Res.53(1): 1–18); Lee et al., 2015 Apidologie 46(3):292-305, Seitz et al., 2016 (in press)), mostly in commercial beekeepers.

We used an expert-based scoring grid to rank beekeepers based on their answers to a management practices questionnaire. We successfully developed a scoring system able to aggregate complex management information in a simple index correlating with increased survivorship of colonies over the winter.

We pursued by subjecting our model to a sensitivity analysis to identify the core management criteria driving the correlation. The top management criteria were identified in various subsets of respondents, resulting in different set of regionally and operation-size specific recommendations. The disparity of top influencing criteria between operation types illustrates the divergence in the beekeeping industry and the need of extension programs to address backyard and commercial beekeepers independently.

Current Risk Assessments for Neonicotinoid Insecticides Do Not Adequately Address Risks to Bumble Bee Queens (Bombus spp.)

Kimberly A. Stoner

The Connecticut Agricultural Experiment Station, New Haven, CT 06511, USA

In the recent literature on neonicotinoid insecticides and bees, the critical questions are: what are field-realistic levels of concentration of neonicotinoid insecticides in the field, and what effects do realistic levels have on the health and survival of bees, and thus on the pollination services they provide? These questions should be evaluated differently for bumble bees (Bombus spp.), particularly for the most vulnerable stage in the bumble bee life cycle, bumble bee queens, than is currently the case in the US and European Union frameworks for risk assessment for effects of neonicotinoids on pollinators.

The potential for exposure of a bumble bee queen to pesticides is greatest when she emerges from overwintering, establishes a nest, and begins incubating a brood clump. She must forage to supply not only her own metabolic needs, but also to turn sugar calories into the wax required in nest construction, to provision cells for larvae with pollen and nectar, and to produce enough heat to incubate the developing brood clump, a major additional metabolic demand. I will present estimates from the literature of the nectar consumption required and the oral pesticide exposure resulting from field-realistic concentrations of neonicotinoids based on these estimates.

POSTER 76

A National Survey of Bumble Bee Pathogens and Parasites Reveals Diverse Associations in Bumble Bee Communities

James P. Strange and Amber Tripodi

USDA-ARS-Pollinating Insect Biology, Management, and Systematics Research Unit, Logan, UT

The use of bumble bees for commercial pollination of crops has been implicated in the movement of pathogens and parasites in agro-ecosystems worldwide. Despite the importance of these pollinators and the growth of the commercial bumble bee industry, little is known about the distribution of pathogens and parasites in bumble bee communities. To understand the distribution of pathogens geographically and across bumble bee species, a total of 4034 bumble bee specimens, representing 26 species, were collected from 18 states across the U.S.A. in 2015. Both microscopy and molecular diagnostics were implemented to test for invertebrate parasites, microbiotic pathogens, and viral presence in each sample. We observed widespread presence of Conopid flies, Crithidia bombi and Nosema bombi, and several viruses. Black Queen Cell virus and Sacbrood virus were the most commonly seen viruses, although little is known about the pathology of these viruses in bumble bees.

Right from the start: Parasites and pathogens of spring bumble bee queens

Amber D Tripodi & James Strange

USDA-ARS-Pollinating Insects Research Unit, Logan, UT, 84341

Bumble bees (Hymenoptera: Apidae: Bombus) are important pollinators of agricultural crops and wild plants. Bumble bees face many health threats, but many of these have been uncharacterized in colony founding queens. Because each queen represents an entire colony, queen health is of paramount importance to population stability. The parasites and pathogens of over 300 queen bumble bees of 16 species from 12 states in the continental United States were characterized using both microscopy and molecular methods. Some pathogens were common and widespread. For example, about one-in-five queens tested positive for Black Queen Cell Virus. Some parasites and pathogens showed regional differences in prevalence, with the queen-castrating nematode, Sphaerularia bombi, notably absent in samples from the southern plains and southeastern regions. Although some parasites and pathogens have been well-characterized in bumble bees, the effects of many detected pathogens are unknown at present. The baseline knowledge generated by this study can guide future experimental investigations into the effects of common parasites and pathogens.

Pollen nutrition drives bumble bee foraging preferences from the lab to the landscape

Anthony Vaudo

Department of Entomology, Center for Pollinator Research, The Pennsylvania State University, 101 Merkle Lab, University Park, PA 16802, (407) 463-0861, advaudo@gmail.com, adv124@psu.edu (may be deactivated at time of conference because of expected graduation in Summer 2016)

Harland Patch

Department of Entomology, Center for Pollinator Research, The Pennsylvania State University, 549 ASI Building, University Park, PA 16802, (814) 867-3023, hmpatch@psu.edu

David Mortensen

Department of Plant Science, Center for Pollinator Research, The Pennsylvania State University, 422 ASI Building, University Park, PA 16802, (814) 865-1906, dmortensen@psu.edu

John Tooker

Department of Entomology, Center for Pollinator Research, The Pennsylvania State University, 113 Merkle Lab, University Park, PA 16802, (814) 865-7082, tooker@psu.edu

Christina Grozinger

Department of Entomology, Center for Pollinator Research, The Pennsylvania State University, 1A Chemical Ecology Lab, University Park, PA 16802, (814) 865-2214, cmgrozinger@psu.edu

Bees forage for pollen as their primary source of proteins and lipids. Because pollen quality varies among plant species, foraging decisions may be driven by how rewarding pollen is nutritionally. To recommend plant species for habitat restoration that supports healthy bee populations, we should determine how pollen nutrition influences bee foraging behavior. We analyzed the pollen foraging preferences of Bombus impatiens to host-plant species in semi-field conditions, then in cages, isolated host-plant pollen and nutritionally modified single-source pollen. We related these preferences to the protein and lipid quality of each pollen source. We then evaluated the nutritional value of corbiculate pollen of foragers in three different landscapes to determine if they meet their pollen preferences in the field. Bombus impatiens increased their foraging rates to host-plant species with pollen of higher protein:lipid ratios (~5:1 P:L), and in cage studies they preferred the same isolate pollen species. When choosing nutritionally modified pollen, workers were again most attracted to 5:1 P:L pollen. In the field, bees collected pollen averaging 4:1 P:L, suggesting that they attempt to defend their nutritional preferences regardless of foraging resources. Thus, pollen nutrition likely drives bee foraging strategies and should guide the selection of host-plant species for conservation protocols.

Effects of crop landscape heterogeneity on pollination services: a modelling approach

Lorena Vieli [1,2], Frank Davis [2], Bruce Kendall [2], Rene Montalba [1]

1. Facultad de Ciencias Agropecuarias y Forestales, Universidad de la Frontera, Temuco, Chile, lorena.vieli@ufrontera.cl
2. Bren School of Environmental Science and Management, University of California Santa Barbara, USA

The provision of crop pollination services is currently at risk because pollinators are undergoing dramatic declines largely caused by agricultural intensification-related processes, such as pesticide inputs, landscape homogenization and loss of natural and semi-natural habitat. At the same time, pollinator dependent crops are increasing worldwide. In this research we explore how pollinator-dependent crops are affecting the provision of this service. Using a spatially explicit model, we simulate different scenarios of the crops' flowering period. Crops classified as early, mid or late flowering in the model generate different levels of crop heterogeneity based on these categories. By varying crop heterogeneity (not crop area) pollinators are affected in terms of their attraction to crop cells and their reproduction rate, which depends on food supply. Increasing crop heterogeneity increases crop pollination services for 99% of the modeled landscapes. The magnitude of the increase is highly dependent on the amount of natural/seminatural areas. The spatial scale of this effect depends on the dispersal distance of pollinators. The provision of crop pollination services can increase at the landscape scale when neighboring crops flower asynchronically and when large monocultures that flower simultaneously are avoided.

POSTER 80

Behavioral and chemical characterization of drone-produced mandibular gland compounds in the honey bee, Apis mellifera

Gabriel Villar [1], Abraham Hefetz [2], Christina Grozinger [3]

1. Pennsylvania State University, Department of Entomology; The Center for Pollinator Research. University Park, PA.
2. Tel Aviv University, Department of Zoology. The Norman and Rose Lederer Chair of Biology. Tel Aviv, Israel.
3. Pennsylvania State University, Department of Entomology; The Huck Institutes of the Life Sciences; Director, The Center for Pollinator Research; University Park, PA.

Pheromones play a critical role in shaping the social structure of societies of social insects, including honey bees. While diverse functions have been ascribed to queen- and worker-produced compounds, few studies have explored the identity and function of male (drone) produced compounds. However, several lines of evidence suggest that drones engage in complex social interactions within and outside of the colony. Here we test the hypothesis that compounds produced in the drone mandibular gland mediate drone social interactions, and detail for the first time the chemical composition of these glands. Investigating the identity of drone-produced compounds is a first step in understanding whether drone-drone and drone-worker interactions are chemically mediated, and may also shed light on how and why some parasites preferentially seek out males as their hosts.

Plant assisted self-medication: Virus challenged bees improve survival with caffeine nectar consumption

Saundra A. Wheeler, Diana Cox-Foster, Ryan Shaner, Edwin Rajotte

College of Agriculture and Industry, The Pennsylvania State University, College, PA 16802

It has been recently reported that nectar alkaloids in bee-pollinated plants have antimicrobial properties that reduce pathogen loads in insect pollinators. Caffeine, an alkaloid found in the nectar and pollen of citrus spp. and coffea spp., induces feeding and recruitment activity in the honey bee Apis mellifera. A no choice test demonstrated that bees with high viral loads self-medicate by consuming large amounts of caffeine at medium level doses and that consumption of caffeine can increase survival and fitness in bees with added virus loads when compared with the control. During choice and multi-choice experiments bees were separated by virus treatment into holding cages and given a choice of caffeine (0ppm, 10ppm, and 25ppm) or a multi-choice of six treatments caffeine (0ppm, 10ppm, and 25ppm), p-coumaric acid (10ppm), or a mixture of both chemicals (caffeine 10ppm/PCA, caffeine 25ppm/PCA). Bees with added virus drank more caffeine than the control when compared to bees with basal viral loads in all tests. In the choice-experiments, bees with basal virus loads drank more control than all other treatments, while bees with added virus drank more caffeine 25ppm. Overall, viral load modulated consumption and caffeine influenced the feeding rhythm in worker bees.

POSTER 82

Exploring the efficacy and feasibility of drone brood removal for Varroa mite (V. destructor) control among small-scale beekeepers in the Midwest

Hannah Whitehead, Casey Hoy, Reed Johnson

The Ohio State University

Experts increasingly point to integrated pest management (IPM) as a strategy for controlling Varroa mites (Varroa destructor). Drone brood removal (DBR) is a non-chemical trapping method that could be applied early in the season as part of an IPM strategy. A handful of studies have shown that DBR is effective, but the method remains relatively underused in the United States. While generally considered too labor intensive for use by commercial beekeepers, it could be well-suited for use by small-scale beekeepers, who suffer particularly high rates of colony loss. This study explored DBR's potential to reduce mid-season mite levels for small-scale beekeepers in the Midwest. Based on an on-farm trial in collaboration with three Ohio beekeepers, DBR significantly reduced mite-to-bee ratios in August. In 19 interviews and over 100 small-scale beekeeper surveys, over 75% of beekeepers indicated that labor was "not important" or only "somewhat important" to their management decisions – compared with 75% who claimed that "reducing chemical use" was "very important". These results suggest that DBR could be a practical addition to IPM strategies for small-scale beekeepers, curbing mite populations while reducing reliance on chemical controls.

Pollinator habitat enhances nesting opportunities for wild bees

Neal M. Williams, Andrew Buderi, Michael Epperly, Logan Rowe, Kevin Tahara, Robbin Thorp

Department of Entomology and Nematology, University of California, Davis

Hedgerows and wildflower plantings are widely promoted in North America as strategies to augment pollinator abundance, diversity and pollination services within agricultural landscapes. These habitats have been well documented to provide important floral resources for wild and managed bees. They also are assumed provide, and even enhance, nesting substrates for pollinator populations; however, empirical tests of their ability to do so is very limited. We tested the ability of wildflower plantings to increase nesting of wild ground-nesting bees in agricultural landscapes in Northern California. Over two seasons we monitored nesting in replicated wildflower plantings and paired control sites using emergence trapping. In the first year of establishment nest density (as measured by trap occupancy) and species richness of bees were significantly greater in wildflower plantings than in control sites. Higher nest density and species richness were maintained in the second year, but they did not increase relative to the first year of establishment. These results suggest that wildflower plantings provide immediate nesting benefit for bees in such landscapes, but they may not continue to augment locally nesting density over time.

POSTER 84

Evaluating field-level fungicide exposure to honey bees during orchard bloom

Julianna Wilson and Jacquelyn Albert

Department of Entomology, Michigan State University

Fungicides are critical tools for managing diseases in Michigan orchards during bloom. Most fungicides are considered safe for use around honey bees (Apis mellifera) based on laboratory toxicological studies on individual bees. New research suggests that fungicides may not be as benign as previously thought. Quantifying field-level exposure to fungicides encountered by honey bees during orchard pollination is the first step in determining whether management practices need modification. At each of three sites (two orchards and one bee-yard), eight commercially managed honey bee hives were sampled for nurse bees and larvae to determine pre-exposure, post-exposure, and persistence. Each sample was screened for common early season pesticides: captan, chlorothalonil, thiophanate methyl, chlorpyrifos, pendimethalin and simazine. Low levels of chlorothalonil were detected in nurse bee samples from at least 50% of hives at orchard sites. Thiophanate methyl in larvae, and the insecticide chlorpyrifos in nurse bees were detected in one of eight hives at the bee-yard. We were surprised to find detectible residues in the non-orchard hives, as there were no orchards within immediate foraging range. This suggests that orchards are an important floral resource in early spring, underscoring the importance of understanding the level of fungicide exposure encountered in these systems.

Cultivating alkali bees for alfalfa seed production

Emily Wine [1] **and Douglas Walsh** [2]

1. Washington State University, Pullman, WA, emily.wine@wsu.edu
2. Washington State University, Prosser, WA

The alkali bee (Nomia melanderi Cockerell) is the world's only intensively managed ground-nesting bee and a highly efficient pollinator of alfalfa (Medicago sativa L.) grown for seed. Since 2008, the price of an alternative pollinator, the alfalfa leafcutting bee (Megachile rotundata F.), has more than quadrupled, increasing growers' reliance on alkali bees. Natural alkali bee beds are found in wet soils with a salty surface contributing to capillary rise. Growers build alkali bee beds by installing subsurface irrigation and heavily salting the topsoil to deter weeds and draw water to the surface. Unlined beds are irrigated constantly and use a substantial amount of water. In previous studies, soil moisture content, soil temperature, and soil salinity were demonstrated to influence the establishment of alkali bee nests and larval development rates. However, no previous study has related alkali bee nesting rates with all three factors. Additionally, no study has followed these alkali bee bed characteristics over the course of an entire season. Preliminary results suggest that soil moisture is strongly correlated with nest abundance ($p<0.0002$), and there is no relationship between soil salinity and nesting rates.

POSTER 85

Nosema spp. Infection levels in feral and managed honey bee (*Apis mellifera*) colonies in southwestern Pennsylvania

Juliana Rangel [1], Brenna Traver [2], Chris Garza [3], Alejandra Gonzalez [1], Brian Trevelline [4], Tom Seeley [5], John Wenzel [6]

1. Department of Entomology, Texas A&M University, College Station, TX
2. Department of Biology, Penn State Schuylkill, Schuylkill Haven, PA
3. Houston Arboretum Conservation Team, Houston, TX
4. Department of Biological Sciences, Duquesne University, Pittsburgh, PA
5. Department of Neurobiology and Behavior, Cornell University, Ithaca, NY
6. Powdermill Nature Reserve, Rector, PA

Among the major challenges to honey bee health is disease caused by the microsporidian gut pathogens *Nosema apis* and *N. ceranae*. Few studies have compared the levels of *Nosema spp.* between feral and nearby managed colonies. To answer this question, we sampled colonies in 2014 and 2015 in a region of southwestern Pennsylvania surrounded by pastures and woodlands across 900 mi^2. Using qPCR to measure DNA copy numbers from 10 individuals per colony, we measured *Nosema spp.* levels from 22 feral and 11 nearby managed colonies as indicators of colony health. Average *N. ceranae* levels were $6.6 \times 10^7 \pm 3.3 \times 10^7$ spores/bee in feral colonies and 1.6 X 107 ± 9.5 X 106 spores/bee in managed colonies, with the percent of bees infected as 48.3% and 47.1% for feral and managed colonies, respectively. Average *N. apis* levels were $2.3 \times 10^3 \pm 2.2 \times 10^3$ spores/bee in feral colonies and $8.7 \times 10^3 \pm 2.9 \times 10^3$ spores/bee in managed colonies, with the percent of bees infected as 2.1% and 14.3% for feral and managed colonies, respectively. The prevalence of *Nosema spp.* Infection is lower in feral colonies, suggesting they are less prone to nosemosis than managed colonies.

SPEAKER INDEX

THANK YOU TO OUR SPONSORS:

Almond Board of California

American Beekeeping Federation

American Honey Producers Association

BASF

Bayer CropScience

Biobest Group

California State Beekkeepers Association

Elsevier Entomology

Ernst Conservation Seeds

Horticultural Research Institute

Koppert Biological Systems

Jasper Wyman & Son

PA State Beekeepers Association

UC Davis

Syngenta

PENN STATE SPONSORS:

Ecology Institute

Huck Institutes of the Life Sciences

College of Ag Sciences

Department of Entomology

Center for Pollinator Research

College of Ag Sciences International Office