APPENDIX D - SAES-422

Format for Multistate Research Activity Accomplishments Report

Note: *This report is submitted each year of an activity's duration and is due 60 calendar days following the annual meeting. The SAES-422 is submitted electronically by AAs into NIMSS. Annual Reports for MRF projects are available to NIFA through NIMSS.*

Project/Activity Number: NC1173
Project/Activity Title: Sustainable Solutions to Problems Affecting Bee Health
Period Covered: 01/01/2019 to 12/31/2019
Date of This Report: 02/20/2020
Annual Meeting Date(s): 01/09/2020

Participants:

Last Name	First Name	Email
Averill	Anne	averill@eco.umass.edu
Burand	John	jburand@microbio.umass.edu
Cowles	Richard S.	richard.cowles@ct.gov
Danforth	Bryan	bnd1@cornell.edu
Delaplane	Keith S.	ksd@uga.edu
Drummond	Frank	frank.drummond@umit.maine.edu
Eitzer	Brian	brian.eitzer@ct.gov
Ellis	James D.	jdellis@ufl.edu
Flenniken	Michelle	michelle.flenniken@montana.edu
Groves	Russell L.	groves@entomology.wisc.edu
Grozinger	Christina M.	cmgrozinger@psu.edu
Harpur	Brock	bharpur@purdue.edu
Hines	Heather	hmh19@psu.edu
Hoover	Kelli	kxh25@psu.edu
Huang	Zachary	bees@msu.edu
Johnson	Reed	Johnson.5005@osu.edu
Kim	Tania	tkim@ksu.edu
Klingbeil	Michele	klingbeil@microbio.umass.edu
Li-Byarlay	Hongmei	hli-byarlay@centralstate.edu
Lopez-Uribe	Margarita	mml64@psu.edu
O'Neal	Matthew E.	oneal@iastate.edu
Patch	Harland M.	hmpatch@psu.edu
Rajotte	Ed G.	egrajotte@psu.edu
Rangel-Posada	Juliana	jrangel@tamu.edu
Sagili	Ramesh R.	sagilir@hort.oregonstate.edu
Schroeder	Declan	dcschroe@umn.edu
Sheppard	Walter	shepp@wsu.edu
Spivak	Marla	spiva001@umn.edu
Stoner	Kimberly A.	kimberly.stoner@po.state.ct.us
Szalanski	Allen	aszalan@uark.edu
Tarpy	David R.	drtarpy@ncsu.edu
Toth	Amy L.	amytoth@iastate.edu
Williams	Geoffrey	williams@auburn.edu
Winfree	Rachael	rwinfree@rci.rutgers.edu
Wu-Smart	Judy	jwu-smart@unl.edu

Brief summary of minutes of annual meeting:
NC1173 Multi-State Project Business Meeting
Minutes taken by Reed Johnson (The Ohio State University)

The NC1173 business meeting was conducted as part of the 2020 American Bee Research Conference (ABRC) co-located with the American Beekeeping Federation 2020 meeting at the Renaissance Conference Center in Schaumburg, IL. The ABRC was held for two days (Jan 9-10, 2020) and serves as the scientific program for the NC1173 multi-state group. An agenda for the ABRC meeting is online (https://aapa.cyberbee.net/abrc-2020/), was submitted in conjunction with this report, and proceedings will be published in the coming months.

The business meeting was called to order at 3:50 PM by chairperson Dr. Judy Wu-Smart from the University of Nebraska. She asked all in attendance to provide their name and e-mail address on a sign-in sheet that was passed around. Dr. Wu-Smart reviewed the current status of the multi-state project. She reported that there are currently 34 members listed in NIMMS (14 of whom were in attendance) representing 22 institutions.

Dr. Wu-Smart reported that the 5-year renewal for NC1173 was successfully submitted in 2019 and thanked the members for their contributions to this document. Proceedings from the 2019 ABRC will be published shortly. There was no Project Director's Report as Dr. William Barker, Project Director for this project, was not in attendance. There was no NIFA Representative Report as Dr. Mary Purcell-Miramontes, former NIFA Rep to the project, has retired and has not been replaced. In the absence of a NIFA Rep there was follow-up about Dr. Purcell-Miramontes' recommendation that the group seek funding through a USDA CAPS project. None of the membership was aware of a current call for proposals that would be appropriate, but we would keep this in mind over the coming year.

The floor was opened for nominations for the position of Chair and Vice-Chair. Each serve 2-year terms and it is customary for the Vice-Chair to be elected to the Chair position at the conclusion of their term. However, there was no one elected to the Vice-Chair position in 2018. Dr. Brian Eitzer nominated Dr. Michelle Flenniken (Montana State University) for the position of Chair, Dr. Ramesh Sagili seconded. No other nominations were made. A vote was taken and Dr. Flenniken was unanimously (14-0) elected Chair of NC1173 for 2020-2022. Nominations were taken for the position of Vice-Chair. Dr. Hongmei Li-Byaraly nominated Dr. Margarita Lopez-Uribe (Penn State) and the nomination was seconded by Dr. Sagili. No other nominations were made. The vote was unanimous (14-0) to elect Dr. Lopez-Uribe as vice-chair for 2020-2022.

Dr. Flenniken moved that the location of the next NC1173 multistate meeting be in conjunction with the American Honey Producers of America (AHPA) and ABRC in Louisiana in December of 2020. Dr. Reed Johnson seconded. The membership voted (14-0) to meet in conjunction with the AHPA and ABRC. Dr. Wu-Smart noted that the annual report for the NC1173 project would be due 60 days after this meeting and encouraged all members to submit their Hatch reporting to her for compilation into the annual report.
At 4:18 Dr. Brian Eitzer moved to adjourn and this was seconded by Dr. Tom Webster.
The group voted (14-0) to adjourn.

NC1173 Objectives

1. To evaluate the role, causative mechanisms, and interaction effects of biotic stressors (i.e. parasitic mites, pests, and pathogens) and abiotic stressors (i.e. exposure to pesticides, poor habitat and nutrition, management practices) on the survival, health and productivity of honey bee colonies as well as within pollinator communities.
2. To facilitate the development of honey bee stock selection, maintenance and production programs that promote genetic diversity and incorporate traits conferring resistance to parasites and pathogens.
3. To develop and recommend "best management practices" for beekeepers, growers, land managers and homeowners to promote health of honey bees and pollinator communities.

Accomplishments:

Objective 1a: (Biotic Stressors: Pests & Pathogens)

Varroa destructor mites are ectoparasitic pests that feed off honey bees and vector a number of viruses which causes severe losses of honey bee colonies each year. NC1173 participants are addressing this problem through the development of novel chemical control options for Varroa destructor mite management (Johnson, OSU). Further, NC1173 members are examining the role pathogens play in colony health (almonds-Flenniken, MSU; Schroeder, UM), how nutrition (specifically phytosterols) may impact viral infection (in orchards-Ramesh OSU and Flenniken, MSU), antiviral defense mechanisms in honey bees (Flenniken, MSU) as well as examining the impact of putative immune stimulants that may reduce virus infection (i.e., fungal extracts and thymol) (Flenniken, MSU and Sheppard, WSU).

Short outcomes: The strong association between *Varroa destructor*, Deformed wing virus (DWV), and high overwintering colony losses (OCL) of honey bees is well established. Three DWV master variants (DWV-A, -B, and -C) have been described, and their role in colony mortality remains an open question. RNAseq analysis confirmed that DWV-A was the most prevalent virus in the apiary, with genetically similar sequences circulating in the apiary pests, suggesting frequent inter-species transmission. In social wasps, samples were grouped further by site, which potentially also influenced viral load. Thus, the apiary invertebrate community has the potential for inter-species (inter-genera) transmission of honey bee-associated viruses, highlighting the importance of considering the wider community in the apiary when considering honey bee health (Schroeder, UM). Testing for new chemical controls of Varroa mites is being conducted in a collaboration between NC1173 members, including researchers at Auburn, the University of Nebraska, the University of Georgia, and USDA-ARS, Alberta Agriculture and Forestry, and the University of Valencia in Spain in work funded by the Foundation for Food and Agricultural Research. Currently, over 20 potential compounds have been tested for efficacy against mites and safety for bees in the laboratory using standardized bioassays. Six promising compounds have been tested on small groups of bees and three have been identified for field testing in colonies.

Outputs: Sheppard determined that fungal extracts were effective at reducing viral loads in naturally infected bees (*published in Scientific Reports 2018*) and Flenniken and Shepard are testing in laboratory-based studies using a model virus. Further NC1173 members, examined the complex mechanisms mediating host-virus interactions in a review (Grozinger and Flenniken, 2019), and demonstrated that the increase in viral load in bees infested in Varroa is due, at least in part, to hemolymph removal by Varroa (Annoscia et al 2019). Thus, a simple mechanical process can trigger viral proliferation.

Objective 1b: (Abiotic Stressors: Pesticides, Forage Availability, Nutrition)

Major abiotic stressors contributing to honey bee health decline include pesticide exposure and malnutrition. NC1173 members are addressing these factors through studies examining the pesticide residue levels found in bee forage (floral nectar and pollen) in ornamental plants treated with systemic insecticides (Eitzer, Stoner, and Cowles, -The Connecticut Agricultural Experiment Station), examining the role existing treelines play as drift barriers to reduce off-target contamination from neonicotinoid-laden dust released during corn planting into forbs growing near corn fields (Wu-Smart, UNL), examining which plants bees are utilizing in natural landscapes and in open spaces near agricultural crops (Kim, Speisman, KSU; Wu-Smart, UNL), and the microbial (bacterial and fungal) communities in bee forage (Danforth, Cornell) to better understand the nutritional requirements of managed and wild bees (*Osmia cornifrons* (*Megachilidae*)) and the role fungicides play on these microbes. Further, some of these issues with pesticide exposure, malnutrition, and or pollination deficits/limitations are being examined in specific cropping systems (apples-Danforth, Cornell; black cherry-Hoover & Grozinger, PSU; corn/soybeans-Wu-Smart, UNL).

Short outcomes: As part of Specialty Crop Research Initiative funded projects 1) *Salvia nemoralis* was treated with applications of systemic insecticides and the nectar was then analyzed for insecticide contamination. These efforts will help us learn more about the potential threat these insecticides pose to pollinators when used as per the label (Eitzer, Stoner, and Cowles, -The Connecticut Agricultural Experiment Station); and 2) preliminary data suggests treelines acting as pesticide drift barriers are effective at reducing contamination in pollinator-friendly habitat adjacent cornfields. These results will help elucidate the environmental fate of neonicotinoid residues, how far residues travel, how much is expressed in plant nectar and pollen, and thus relevant field exposure levels for non-target beneficial insects (Wu-Smart, UNL).

Outputs: Research on "Bee Lawns" (Spivak UMN) formed the basis for a Minnesota legislative initiative, passed in 2019, called "Lawns to Legumes" in which communities and homeowners will receive cash incentives to establish pollinator habitat through a competitive process: https://bwsr.state.mn.us/lawns-legumes. NC1173 members (Grozinger & Patch -PSU) developed an insecticide toxic load index, which integrates data from multiple government databases to provide a measure of the total toxicity of all the pesticides applied to a particular crop in a particular state (Douglas et al 2020). Development of this index allowed to examine patterns in insecticide use and toxicity over the last ~20 years, and demonstrated a significant increase in toxic load, due primarily to neonicotinoid seed treatments. This index has been incorporated into our Beescape portal (see Obj3 below) and is being used in large scale analyses of bee health. Together with a working group supported by the NSF Socio-Environmental Synthesis Center, a review examining the sociological aspects of pesticide use and regulation and intended to help understand the non-biological drivers of pesticide use patterns was published (Sponsler et al 2019). Funding through North Central IPM Center (USDA NIFA #2018-70006-28883) was acquired to form the IPM4Bees Working Group to foster learning, collaboration, and information/resource sharing among researchers, extension professionals, and other stakeholders that work in honey bees, native bees, and bee-related integrated pest management (IPM) (O'Neal and Cass (ISU), Wu-Smart, UNL, Milbrath, MSU). The IPM4Bees Midwest Working Group held a symposium and a workshop. (Symposium: Monitoring, Mitigation, and Miticide: What IPM Strategies Improve Honey Bee and Native Bee Health? at the 2019 Entomological Society of America North Central Branch meeting in Cincinnati, Ohio. The two-day workshop was held at Iowa State University in Ames, Iowa (July, 2019), was attended by 34 participants (researchers, students, educators, and beekeepers) from 8 different states, and included a field day at the ISU

apiary with demonstrations on Varroa mite monitoring/management and the Prairie strips (a conservation practice that protects soil and water while providing habitat for wildlife). The group has secured another round of funding to hold another symposium (North Central ESA conference, Oklahoma) and workshop at Michigan State University in 2020.

Objective 2: (Genetics, Breeding, & Diversity)
Breeding mite and disease resistant traits in honey bee stock and diversifying honey bee genetics and selection efforts are more sustainable solutions to address the pest and pathogen issues in honey bees and is long-term goal for NC1173 members. Efforts include studies to examine how establishing high-yield nectar crops support high densities of honey bee colonies required for mating yards in honey bee genetic improvement programs (Eitzer, Stoner, Cowles -Connecticut Ag Station). Further, NC1173 members (Grozinger, PSU) demonstrated that, using commercially available honey bee stocks, there was no variation in winter survival in central Pennsylvania based on geographic origin of the stocks. Rather, colony size and apiary location were the most important drivers of winter survival (Doke et al 2019).
Short outcomes: Purdue University (Harper) breeding program with mite resistant traits has been successfully made available in seven US States. Additionally, honey bee queen improvement project (Eitzer, Stoner, Cowles -Connecticut Ag Station) was handed over to the Connecticut Queen Breeders' Association. In its first year of actively producing queens, the emphasis was on using known mite resistant lines with the Varroa sensitive hygiene (VSH) trait. There remain concerns that the bees from this line have several low-fitness traits. Hybridizing VSH bees with healthy "survivor" bees obtained from colonies extracted from structures will probably be necessary to obtain the combination of good hygienic traits and fitness characteristics (hoarding honey, lack of obsessive uncapping of brood cells) to be acceptable for practical use by beekeepers.
Outputs: Studies conducted on the chemical signals used to attract male drones to honey bee queens determined that mated queens produced a blend that was less attractive than virgin queens (Villar et al 2019) (Grozinger, PSU). This information can potentially be used to improved selective mating. NC1173 members worked directly with over 2,000 beekeepers and nearly 1,000 members through 16 extension programs including two extensions courses, and invited presentations in four states on honey bee genomics (Harpur, PU).

Objective 3: (Management)
Management practices to maintain healthy honey bees and landscapes that support pollinators are in high demand and recommendations continue to evolve with new research. Therefore, NC1173 members strive to engage with stakeholders to better provide the most up-to-date, science-based recommendations to beekeepers, pesticide applicators, farmers, homeowners and policy makers. Recommendations include how to better manage pests and pathogens in honey bees, enhancing landscapes for pollinators, and options to reduce exposure or mitigate effects of pesticides. NC1173 members conducted studies to identify the most attractive and nutritionally beneficial species of plants in urban (Sponser et al 2020, Erickson et al 2019) and agricultural or semi-natural settings (Treanore et al 2019, Russo et al 2019).
Short outcomes: NC1173 members (López-Uribe and Underwood PSU) have worked with a group of 30 beekeepers to develop the protocol for best management practices for beekeepers that have different philosophies towards chemical treatments (Underwood et al 2019). Together, they developed protocols for the project and continuously received feedback about hive management. After the OREI project, many of them are incorporating organic management practices in their operations. The OREI stakeholder group meetings (led by López-Uribe and

Underwood) have created an opportunity for interactions between beekeepers with different philosophies about management practices. All statehooders have been continuously informed about the results of the project and many of them have expressed an interest in incorporating the management practices that we are developing into their operations. Our average survival with organic management practices has been 85% for the last two years.

NC1173 members also provide a number of courses for stakeholders. For example, (Wu-Smart, UNL) provided a total of 15 Beekeeping workshops (7) and learning series (8), as well as 9 practical training sessions through workshop field days (5) and open apiary sessions (4) offered in 5 cities across Nebraska which reached 748 beekeepers from Scottsbluff (Scotts Bluff County) to Lincoln (Lancaster County). Course participants also included people from neighboring states Kansas, Iowa, Colorado, South Dakota, Wyoming, and Missouri. Provided 13 introductory/exploratory level classes (Year 1 and Year 2 Beekeeping) to 673 new or aspiring beekeepers to educate about basic honey bee management and IPM strategies for honey bee pests and diseases. Provided 1 advanced courses (Pest and Pathogen Diagnostics) to 30 beekeepers. The advanced courses are designed to help beekeepers with 5+ years of experience expand their skills so that they may expand their businesses and operations in new directions. As a result of our Introductory Beekeeping Course in Scottsbluff, NE, the class participants (group of 40 new beekeepers) created a new Facebook group (Western Nebraska Beekeepers) on the last day of the course so that they could stay better connected and continue to engage in community learning. Zachary Huang gave 9 talks to beekeepers on queen rearing and varroa mite management. Michelle Flenniken gave 3 talks to beekeepers and agriculture extension specialists on the impact of pathogens on honey bee colony health.

Outputs: In Spring 2019, in collaboration with the Philadelphia-based company Azavea, a collaborative team from Penn State, Dickinson College, University of Minnesota and University of California Davis published our online portal "Beescape" (see Beescape.org). In the Beescape interactive map, users can enter their address or click on their location to obtain metrics on local landscape quality for bees. Users can obtain these metrics at either the 3 km or 5 km radius scales. Metrics include: (1) Floral Resources in Spring ("Spr. Floral"), Summer ("Sum. Floral"), and Fall ("Fall Floral") (2) Predicted Insecticide use and toxicity levels in the surrounding landscape ("Insecticide") (3) Nesting resources for wild bees ("Nesting"). At present, our interactive map is available for Pennsylvania, Indiana, Illinois, New York, West Virginia, Michigan, and Wisconsin though we hope to continue adding states as data become available. We also invite Beescape users to provide us with information through a "fall" and "spring" survival survey so we can assess winter survival. As of December 2019, Beescape contains the locations for 1,280 user-generated "apiaries" from 519 unique Beescape users.

Impacts

Purdue University (Harpur) Bee Field day draws 150 beekeepers from across Indiana. Our Insemination course brings in 30 beekeepers from across the US and trains them to create sustainable breeding programs. Our queen rearing course trains beekeepers to locally produce their own breeding queens and create sustainable operations. Each of these extension programs are evaluated with surveys. The extension talks that Dr. Harpur provides have quantifiable impacts on the beekeeping community. His talks increase beekeeper's understanding of their colonies: 92.8% of beekeepers attending Dr. Harpur's extension talks have an increase in their understanding of topics after the presentation. 85.7% of talk attendees rank Dr. Harpur's

extension presentations on genetics as 'very inspiring'.

Penn State's Center for Pollinator Research held a workshop with the Center for Science and the Schools for thirteen K-12 teachers. This workshop provided teachers with information on pollinator biology and ecology, as well as authentic research practices in this domain. We developed a series of lesson plans to support teacher activities which will be posted by Spring 2021 on the Center for Pollinator Research website. Through Penn State's Integrative Pollinator Ecology Graduate Training Program (funded by the USDA-NIFA-NNF program) we are training nine graduate students to holistically tackle issues in pollinator health and biology. One student graduated and accepted a tenure track faculty position in the Penn State Libraries.

We conducted a series of studies to identify the most attractive and nutritionally beneficial species of plants in urban (Sponser et al 2020, Erickson et al 2019) and agricultural or semi-natural settings (Treanore et al 2019, Russo et al 2019).

University of Nebraska-Lincoln (Wu-Smart) received extension funding through the USDA-NIFA Beginning Farmer Rancher Development Program to begin the "The Great Plains Regional Training For Beginning Beekeeping Farmers (GPMB)" program that provides a structural framework to standardize beekeeping management training, address misinformation, and allow researchers and beekeepers to respond to emerging honey bee health issues in the region. Activities are designed to 1) improve profitability through adoption of success-proven colony management skills and integrated pest management, 2) increase training opportunities by amending existing and outdated educational materials and making them assessable to instructors, and 3) provide targeted training opportunities to underserved communities. External collaborator, the Center for Rural Affairs (CFRA) will help expand learning opportunities to socially-disadvantaged and or under-served communities, including women, military veterans, Latinos, and Tribal groups. The GPMB program started in April 2019 and currently has 250+ beekeepers from NE, IA, KS, MO, and WY registered. Of those members, 132 or 55% are females. Additionally, we have 5 Native American members, 5 Hispanic members, and 75 members of the program that are Veterans or currently serving in the armed forces (34% of total members), further demonstrating GPMB's ability to reach and maintain members from an underserved community. Workshop evaluations revealed participants experienced a 50% increase in training comprehension, and 80% responded they were Completely Likely to apply use of IPM and land stewardship practices discussed in the course. For more information: https://gpmb.unl.edu/

Montana State University's Pollinator Health Center (http://www.montana.edu/pollinators/) Montana State University's pollinator health center provided information for pollinator friendly plantings at several volunteer days at the 0.5 acre pollinator garden and bee yard. In addition, the center hosted a Pollinator Symposium on April 18, 2019. The event featured short research talks by MSU graduate students, pollinator films, and a Q&A session with local bee experts including Michelle Flennken, Co-director of the Pollinator Center, and Casey Delphia, native/wild bee expert; approximately 100 people attended.

Activities:

Brock Harpur, Purdue University

Is currently evaluating genetic and phenotypic variation among honey bee stocks, including feral populations.

Indicators:

NC1173 members (Witzer, Stoner, Cowles, Conn Ag Exp Station) carried out a 3- year project "Creating and Improving Pollinator Habitat" funded by a Specialty Crop Block Grant. Participants in Pollinator Habitat conferences reported planting at least 73 acres of new pollinator

habitat, and changing management practices to favor pollinators on 296 acres. Additional areas of pollinator habitat as a result of this project come from the Connecticut Department of Transportation, which has planted pollinator habitat on 8 sites and reduced mowing on 51 sites around the state. The Pollinator Pathway project is also an outcome of the Pollinator Habitat conferences. The Pollinator Pathway project has established pathways in 20 Connecticut towns, and is in the process of organizing pathways in 60 more, with new requests coming in frequently. A survey of the Pollinator Pathway network in fall 2019 documented new plantings of 141 trees, 835 shrubs, and 13 acres, with 15 additional acres managed for pollinator habitat with reduced mowing and removal of invasive plants. In part due to NC1173 members (e.g. Reed Johnson) research and outreach activities, the application of insecticides to almonds during bloom, when bees are present, has been reduced by 55% from 2014 (179,000 acres) to 2017 (78,000 acres), as reported in California Department of Pesticide Regulation statistics. These data indicate that pesticide applicators are less likely to include insecticides in tank-mixes applied during bloom and are following Best Management Practices to protect honey bees.

Summary table and list of publications by topic reported by NC1173 committee members for 2019. NC1173 authors are indicated in bold.

Publications by topic	2019
Obj 1: Biotic (Pests & pathogens)	4
Obj 1: Abiotic (Pesticides, nutrition, landscapes)	18
Obj 2: Genetics, Breeding, Diversity	7
Obj 3: Management	7
Total	36
Publications with >1 NC1173 authors	10

NC1173 Member Publications

Objective 1a: Biotic Stressors (Pests & pathogens)

Annoscia, D., Brown, S.P., Di Prisco, G., De Paoli, E., Del Fabbro, S.D., Frizzera, D., Zanni., V., Galbraith, D.A., Caprio, E., **Grozinger, C.M.,** Pennachio, F. and F. Nazzi., "Haemolymph removal by Varroa mite destabilizes the dynamical interaction between immune effectors and virus in bees, as predicted by Volterra's model" *Proc Roy Soc Bio* 286 (1901), 20190331 (2019).

Bretell LE, **Schroeder DC**, Martin SJ. 2019. RNAseq analysis reveals virus diversity within Hawaiian apiary insect communities. *Viruses* 11, 397 doi:10.3390/v11050397.

Grozinger, C.M. and **Flenniken, M**.L. (**2019**) Bee Viruses: Ecology, Pathogenicity, and Impacts. *Annual Review of Entomology Vol. 64:205-226, doi.org/10.1146/annurev-ento-*

Kevill JL, de Souza FS, Sharples C, Oliver R, **Schroeder DC**, Martin SJ. 2019. DWV-A lethal to honey bees (Apis mellifera): A colony level survey of DWV variants (A,B and C) in England, Wales and 32 states across the US. *Viruses* 11, 426 doi:10.3390/v11050426.

Li, W., C. Wang, **Z.Y. Huang**, Y. Chen, R. Han. 2019. Reproduction of Distinct *Varroa destructor* Genotypes on Honey Bee Worker Brood. Insects. 10:372. https://doi.org/10.3390/insects10110372

Wagoner K, **Spivak M**, Hefetz A, Reams T, **Rueppell O.** 2019. Stock-specific chemical brood signals are induced by *Varroa* and Deformed Wing Virus, and elicit hygienic response in the honey bee. *Scientific Reports*. 9:8573. doi.org/10.1038/s41598-019-45008-2

Objective 1b: Abiotic Stressors (Pesticides, nutrition, landscapes)

Beasley, D. E., Fitzgerald, J. L., Fowler, A., Keleher, K., **López-Uribe**, M. M. (Co-Author, 20%), & Dunn, R. R. (2019). Do Bee Wings Adapt for Flight in Urban Environments? *Southeastern Naturalist, 18*(2), 183-191.

Cusser, S., Grando, C., Zucchi, M. I., **López-Uribe,** M. M. (Co-Author, 10%), Pope, N. S., Ballare, K., Luna-Lucena, D., Almeida, E. A., Neff, J. L., Young, K., & Jha, S. (2019). Small but critical: semi-natural habitat fragments promote bee abundance in cotton agroecosystems across both Brazil and the United States. *Landscape Ecology, 34*(7), 1825-1836.

Douglas, M.R., Sponsler, D.B., Lonsdorf, E.V. and **C.M. Grozinger**. "County-level analysis reveals a rapidly shifting landscape of insecticide hazard to honey bees (Apis mellifera) on US farmland" *Scientific Reports* 10(1), 1-11, (2020).

Lane, I., Watkins, E., & **Spivak, M**. 2019. Testing the establishment of eight forbs in mowed lawns of hard fescue (*Festuca brevipila*) for use in pollinator conservation. HortScience 54(12). DOI: https://doi.org/10.21273/HORTSCI14336-19

Lane, I., Watkins, E., & **Spivak, M**. 2019. Turfgrass Species Affect the Establishment and Bloom of Kura Clover *(Trifolium ambiguum)* in Lawns. HortScience, 54(5), 824–828. doi: 10.21273/HORTSCI13779-18

Lamke, K. 2019. A Descriptive Study of Wild Bees (Hymenoptera: Apoidea: Apiformes) and Angiosperms in Tallgrass prairie grasslands of southeastern Nebraska. M.S. Thesis (Advisor: **Judy Wu-Smart**) Department of Entomology, University of Nebraska-Lincoln.

Lau, P., V. Bryant, **J.D. Ellis, Z.Y. Huang**, J. Sullivan, D.R. Schmehl, A.R. Cabrera, J. Rangel. Seasonal variation of pollen collected by honey bees (Apis mellifera) in developed areas across four regions in the United States. PLOS ONE, 2019; 14 (6): e0217294 DOI: 10.1371/journal.pone.0217294

Mollet, K. 2019. Promoting bee communities through habitat enhancements on public and private lands in Nebraska. M.S. Thesis (Advisor: **Judy Wu-Smart**) Department of Entomology, University of Nebraska-Lincoln.

Ostiguy N, Drummond FA, Aronstein K, **Eitzer B, Ellis JD, Spivak M, Sheppard WS**. 2019. Pesticide exposure to honey bees in a four-year nationwide study. *Insects*, 10, 13, doi:10.3390/insects10010013.l

Richardson, R. T., H. R. Curtis, E. G. Matcham, C.-H. Lin, S. Suresh, D. B. Sponsler, L. E. Hearon, and **R. M. Johnson**. 2019. Quantitative multi-locus metabarcoding and waggle dance interpretation reveal honey bee spring foraging patterns in Midwest agroecosystems. Mol. Ecol. 28: 686–697.

Richardson, R. T. 2018. Molecular analysis of honey bee foraging ecology. Ph.D. Dissertation (Advisor: **Reed Johnson**). Department of Entomology, The Ohio State University.

Russo, L., Keller, J., Vaudo, A., **Grozinger, C.M.,** K. Shea. "Warming increases pollen lipid concentration in an invasive thistle, with minor effects on the associated floral-visitor community" *Insects* 11(1) 20 (2020)

Spivak M, Goblirsch, M, Simone-Finstrom M. 2019 Social-medication in bees: The line between individual and social regulation. *Curr. Opinion Insect Science* 33:49-55. https://doi.org/10.1016/j.cois.2019.02.009

Sponsler, D.B., **Grozinger, C.M.,** Hitaj, C., Rundlöf, M., Botías, C, Code, A., Lonsdorf, E.V., Melathopoulos, A.P., Smith, D.J., Suryanarayanan, S., Thogmartin, W.E., Williams, N.M., Zhang, M., and M. R. Douglas. Pesticides and pollinators: a socioecological synthesis. *Science of the Total Environment* 662: 1012-1027 (2019).

Stoner, Kimberly A., Richard S. Cowles, Andrea Nurse, and **Brian D. Eitzer**. 2019. Tracking Pesticide Residues to a Plant Genus Using Palynology in Pollen Trapped from Honey Bees (Hymenoptera: Apidae) at Ornamental Plant Nurseries. *Environ. Entom.* 48(2): 351-362.

Wade, A., C.-H. Lin, C. Kurkul, E. R. Regan, and **R. M. Johnson**. 2019. Combined Toxicity of Insecticides and Fungicides Applied to California Almond Orchards to Honey Bee Larvae and Adults. Insects. 10.

Yang, W., C. Zhang, C. Li, **Z.Y. Huang,** X. Miao. 2019. Pathway of 5-hydroxymethyl-2-furaldehyde formation in honey. J Food Sci Technol. https://doi.org/10.1007/s13197-019-03708-

7.

Zhang, C., S. Pokhrel, Z. Wu, X. Miao, **Z. Y. Huang***, W. Yang. 2019. Longevity, food consumption and foraging performance of Apis cerana and Apis mellifera in mixed colonies. Apidologie. https://doi.org/10.1007/s13592-018-0626-7.

Objective 2: Genetics, Breeding, Diversity

Andersen, R.E., Hong, S.J., Lim, J.J., Cui, M., **Harpur, B.A**., Hwang, E., Delgado, R.N., Ramos, A.D., Liu, S.J., Blencowe, B.J., & Lim, D.A. (2019). The Long Noncoding RNA Pnky Is a Trans-acting Regulator of Cortical Development In Vivo. Developmental Cell. https://doi.org/10.1016/j.devcel.2019.04.032.

Doke, M.A., McGrady, C.M., Otieno, M., **Grozinger, C.M., and M. Frazier**. "Colony size, rather than geographic origin of stocks, predicts overwintering success in honey bees (Hymenoptera: Apidae) in the northeastern United States" Journal of Economic Entomology 112(2): 525-533 (2019).

Harpur,B.A., Guarna, M.M., Huxter, E., Higo, H., Moon, K-M., Hoover, S.E., Ibrahim, A., Melathopoulos, A.P., Desai, S., Currie, R.W., Pernal, S.F., Foster, L.J., and Zayed, A. (2019). Integrative genomics reveals the genetics and evolution of the honey bee's social immune system. Genomes Biology and Evolution. DOI: 10.1093/gbe/evz018

Kapheim, K.M., Pan, H., Li, C., Blatti, C., **Harpur, B.A.**, Ioannidis, P., Jones, B.M., Kent, C.F., Ruzzante, L., Sloofman, L. and Stolle, E. (2019). Draft genome assembly and population genetics of an agricultural pollinator, the solitary alkali bee (Halictidae: *Nomia melanderi*). G3: Genes, Genomes, Genetics. DOI: 10.1534/g3.118.200865.
López-Uribe, M. M., Jha, S., & Soro, A. (2019). A trait-based approach to predict population genetic structure in bees. Molecular Ecology, 28(8), 1919-1929.

Ma, R., **Rangel, J., and C.M. Grozinger**. "Honey bee (*Apis mellifera*) larval pheromones may regulate gene expression related to foraging task specialization" *BMC Genomics* 20(1): 592 (2019)

Villar, G., Hefetz, A., and **C.M. Grozinger**. "Evaluating the Effect of Honey Bee (Apis mellifera) Queen Reproductive State on Pheromone-mediated Interactions with Male Drone Bees" Journal of Chemical Ecology 45(7): 588-597 (2019).

Objective 3: Management

Erickson, E., Adam. S., Russo, L., Wojcik, V**., Patch, H.M., and C.M. Grozinger**. "More than meets the eye: The role of ornamental plants in supporting pollinators" Environmental Entomology doi: 10.1093/ee/nvz133 (2019).

Lee, KV, Goblirsch M, McDermott E, **Tarpy DR, Spivak M**. 2019. Is the brood patterns within a honey bee colony a reliable indicator of queen quality? *Insects* 10, 12; doi:10.3390/insects10010012

Ramer H, Nelson K, **Spivak M,** Watkins E, Wolfin J, Pulscher M. 2019. Exploring park visitor perceptions of 'flowering bee lawns' in neighborhood parks in Minneapolis, MN, US.

*Landscape and Urban Planning.*189: 117-128.
https://doi.org/10.1016/j.landurbplan.2019.04.015

Russo, L, Vaudo, A.D., Fisher, C.J., **Grozinger, C.M**., and K. Shea. “Bee community preference for an invasive thistle associated with higher pollen protein content” Oecologia 190(4): 901-912 (2019)

Sponsler, D.B., **Grozinger, C.M**., Richardson, R., Nurse, A., Brough, D., **Patch, H.M**., and **K. A. Stoner**. " A screening-level assessment of the pollinator-attractiveness of ornamental nursery stock using a honey bee foraging assay" Scientific Reports 10(1), 1-9

Treanore, E., Vaudo, A.D., **Grozinger, C.M.,** and S.J. Fleischer. "Examining the nutritional value and effects of different floral resources in pumpkin agroecosystems on Bombus impatiens worker physiology" Apidologie 50(4), 542-552 (2019).

Underwood, R., Traver, B. E., & **López-Uribe**, M. M. (2019). Beekeeping management practices are associated with operation size and beekeepers’ philosophy towards in-hive chemicals. Insects, 10(1), 10.

Simone-Finstrom, M., **Niño, E., Flenniken, M., Wu-Smart, J. Y.** Proceedings of the 2019 American Bee Research Conference. (2nd ed., vol. 11, pp. 88). Proceedings of the 2019 American Bee Research Conference. Insects.

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*Limited to three pages or less exclusive of publications, details may be appended.