Statement of Research Interests and Objectives

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Overview. Applied insect ecology, pollination ecology, insect communication, and conservation form the core of my research program. Specifically, my research focuses on understanding communication pathways in insects (inter- and intra-specific communication), and insect-resource interactions. I am interested in using behavioral ecology, physiology, and chemical ecology to advance our understanding of basic insect ecology (foraging, mate location) and implications for insect-plant interactions. The outcomes of my research are focused on applied solutions for management (e.g., pest management) and conservation (e.g., develop monitoring techniques threatened and endangered insects). In my research, I use a combination of laboratory behavioral bioassays, field experiments and surveys, crowdsourcing, and chemistry and chemical ecology methods (e.g., compound identification via mass spectrometry [GC-MS] and electro-antennogram [EAD]), as well as disciplines in physics (e.g. programing Arduino to mimic flashing wing beat frequencies). Capitalizing on its diversity, the overall goal of my research program has always been to bridge the gap from conceptual science to application.

Multi-modal communication pathways - My doctoral work at Simon Fraser University and collaborative research with Western Australian University scientists and the Australian Wool Innovation Ltd., investigated how adult blow flies (Family Calliphoridae) use combinations of semiochemicals, visual cues and signals, to locate food and oviposition resources, and mates. Despite of the economic and forensic importance of blow flies, little is known about the adult phase. Newly-eclosed flies require carbohydrates to fuel their flight and daily activities, and a large amount of protein for their reproductive development; I found that flies can use pollen protein to fulfil their physiological requirements, and that they forage for flowers using specific floral odor and color (yellow, white, and ultraviolet), thus challenging the paradigm that blow flies require animal protein (feces, carrion) for reproductive development. This work has important implications for pollination ecology, as flies are known efficient pollinators for many economically-important crops and native plants. I also found that blow flies do not have a sex pheromone, and that sexually mature males locate and recognize potential mates using wing beat frequency cues from flashes of reflected light. Gravid females seek out recently deceased animal carcasses as oviposition sites using a key semiochemical, dimethyl trisulfide (DMTS), and response to DMTS increases when paired with dark animal pelt-mimicking colors. However, DMTS is found in both feces and carrion, and I found that indole is the key indicator semiochemical of a food rather than oviposition resource. Overall, my doctoral research contributed to the understanding of insect foraging, and emphasized the importance of studying foraging decisions based on physiology and development stage. Ultimately, this research produced 7 manuscripts and lead to a patented multi-purpose commercial flytrap used to mass-trap and suppress fly populations. I also used insights from my blow fly work to co-develop a novel semiochemical-infused bait for a variety of rat species (patent pending).

At Ohio University, supported by the Delaware County Board of Commissioners, I have continued this theme by investigating resource foraging and communication pathways of midge flies (Family Chironomidae). While still in the early phase, the goal of this project is to provide a sustainable and cost effective integrated pest management plan for the elimination of pest midges in wastewater treatment plants by exploiting midge visual cues (wing beat frequency, polarized light) involved in mating and oviposition, to identify alternative methods for managing, and assessing commonly used larvicides against pestiferous midge larvae. Midges are quite a problem in waste water treatment plants, thus such work is widely applicable.

Future work - My work in this area has opened new avenues for research on, 1) recognizing the potential of flies as pollinators, novel pest management technologies (flashing wing-beat frequencies, polarized) for manipulating both sexes for many fly families (solitary and swarming) in urban and agricultural settings. The importance of blow flies as pollinators and their use flowers as a protein resource provides impetus to continue to investigate the floral semiochemicals that mediate the attraction of flies, opening new ways to understand the role of flies as pollinators. The finding that blow flies and midges use flashy wing beat frequencies to locate mates is novel and opens new avenues for investigating the occurrence and role of such signals for other insects (specifically those that vector pathogens that cause disease), and contribute to sustainable and environmentally-friendly pest management.

Interactions between insects and woody plants: forest entomology, forest insect chemical ecology, and insect conservation - Saproxylic beetles provide important ecosystem services, are biological indicators of forest health, and can be used as conservation surrogates for other forest species. Therefore, it is crucial to understand their communication pathways, and to develop viable and powerful monitoring methods for assessing their distribution and abundance. For my MSc research at SUNY Environmental Science and Forestry, I found that non-social Cerambycidae (*Monochamus scutellatus*) provide information in cuticular hydrocarbon profiles about their sex and ontogenetic development. For my current research in Romania (in collaboration with USDA, semiochemical industry, and Romanian and US universities), I used pheromone traps to assess the diversity and conservation status of endangered, vulnerable, and data deficient Longicorn Beetles in traditionally-managed landscapes of Eastern Europe. My survey is the first of its kind in Europe, and contributes a better understanding of pheromone diversity and phenology in Eastern European Longicorn Beetles. The novel application of pheromone techniques to insect conservation (these pheromones are usually used in pest control) opened new avenues for developing rapid insect diversity assessments. To fund this research, I secured a research grant from the Mohamed bin Zayed Species Conservation Fund (2015-16); along with the novelty of the longicorn monitoring techniques, this work provided important avenues for conservation outreach (via printed educational material, short film, workshops), as many of these species are both highly charismatic, and declining in Europe.

***Future work* -** The work on Romanian Longicorn Beetles opened many opportunities to expand our knowledge on the pheromone phenology of Cerambycidae, as well as the pollination ecology of longicorn beetles; for example, many beetle species in this system are grassland flower specialists, and future research could investigate the role of Cerambycidae beetles in maintaining plant diversity in grassland and forest ecosystems. Building on my current work, my Romanian collaborators and I are also developing large scale project to develop a comprehensive conservation and monitoring plan for both pest and endangered beetles in Carpathian deciduous forests (with several regional EPAs, environmental NGO's and the Romanian Ministry of Environment).

Interactions between insects and herbaceous plants: Pollination ecology and manipulation -

Global concern regarding pollinator decline has intensified our interest in understanding pollinator ecology and managing pollinator-supportive landscapes. Providing floral habitats that favor pollinators will strongly influence pollinator services in natural environments and, with the increase in pollinator friendly cities, increase survival in urban landscapes. At Ohio University and in collaboration with colleagues at Simon Fraser University, my research has focused on understanding floral attractiveness to pollinators and investigated olfactory and visual cues used by the skunk cabbage beetle (Family Staphylinidae) to locate its host flower. At Ohio University, I have concentrated on developing landscape management practices and conservation tools to support a wide variety of pollinators. I use citizen science as a tool for identifying floral preferences of non-conventional pollinators, such as flies, and developing strategies for increasing pollinator visitation in home gardens. By passively crowdsourcing data from thousands of images posted on social media resources worldwide, and using statistical modeling followed by lab and field experiments, we found evidence that a large number of fly Families exploit floral shape as the primary visual cue during foraging and are visiting a variety of flowers while caring pollen, indicating that flies are playing a significant role as pollinators to a variety of flowers.

***Future work* –** I plan to expand this work to include all pollinators (solitary bees, beetles), as well as their predators (primarily spiders). I will also implement field trials to investigate the importance of ultraviolet floral patterns for attraction of various insect families. This research will provide important information on types of flowers and habitats that favor pollinators, as well as best practices for manipulating pollinators to increase seed set in both natural and urban settings (i.e. pollinator-friendly cities).

Using experimental research as a teaching and mentoring tool -

Awareness is the first key to success in engaging undergraduate students. As an undergraduate research mentor, I am mindful of students' potential interest in research and I gauge this by getting to know my students and advisees during class or meetings, and provide the right guidance about getting involved. I firmly believe that involving students in research is a great way to enable them to reach their full potential and ignite a passion for research. I involve them by developing methods for hypotheses that are made up of many small projects or experiments; undergraduate students can develop ownership of their slice, often leading to independence. During my doctoral studies at Simon Fraser University I mentored 12 undergraduate students. Of these, 10 received varying amounts of class credits for their work and 2 were able to secure undergraduate research funding through NSERC (Canada's equivalent of NSF). At Ohio University, I mentored an additional 6 research students funded through the Program to Aid Career Exploration (PACE) and the Rush Elliot Fund. All 18 undergraduates are or will be co-authors on the manuscripts emerging from my research, one of them is first author on a paper published in BMC Biology (Eichorn et al. 2016. How flies are flirting on the fly. BMC Biology.15:2). Such experience and credentials provide students with a huge boost should they seek entry into post-graduate research or professional programs. I am committed to integrate undergraduate at Denison University, and to offer students a rich, rewarding and useful learning experience.

Summary. The overall goal of my research is to develop environmentally sustainable and novel ways by which we can use entomology to contribute to societal wellbeing, with a focus on both urban and natural settings. In pursuit of this goal, I have developed practical skills for field and laboratory experiments, data analysis and interpretation leading to publications and products for industrial and residential use.