Past and Current Research

My passion for entomological research is fueled by the remarkable diversity of forms and ecologies that insects have evolved over time. My expertise lies in the molecular and morphological systematics of beetles, which I have used to inform taxonomy and investigate evolutionary questions. My work has predominantly focused on darkling beetles (Tenebrionidae), a species-rich group with over 30,000 members, utilizing methods applicable across various insect taxa and other life forms. Recently I have also begun expanding into research areas focused on insect biodiversity more broadly.

My doctoral research focused on the darkling beetle tribe Sepidiini (Tenebrionidae). This tribe, comprising around 1,000 species, is notable for its morphological diversity and unique behaviors, such as substrate tapping, which earned them the nickname “toktokkies.” Despite their ecological and evolutionary significance, taxonomic work on Sepidiini had been sparse for decades. To address this gap, I employed Sanger sequencing to generate the first published phylogeny of Sepidiini, using five gene fragments. Although this initial work established the tribe's phylogenetic framework (Gearner et al. 2021, Kaminski et al. 2021), deeper nodes exhibited weak support, likely due to limited data. To refine this, I utilized targeted enrichment techniques to capture approximately 600 phylogenetically informative loci, leveraging resources from the Smith lab and my fieldwork. This dataset, including about 150 taxa and a detailed morphological matrix of over 150 characters for more than 70 taxa, was analyzed using Maximum Likelihood and Bayesian methods on the Purdue High Performance Computing Cluster (HPC).

I also utilized these results to perform comprehensive taxonomic revisionary work and investigate the evolution of substrate tapping behavior. Phylogenomic and morphological evidence led me to establish a new subtribe, Stenethina. I also revised another subtribe (Hypomelina), which includes nine genera and 45 species, by examining over 300 specimens and creating morphology matrices. This work resulted in redescriptions, synonymizations, and new species descriptions, as well as an updated key to genera and species.

Many members of Sepidiini are known for their substrate-tapping behavior. However, tapping patterns have only been documented for a handful of species. To better understand this behavior and its origin, I conducted fieldwork to observe and record substrate-tapping behavior across Sepidiini taxa. This project was funded through awards I obtained through the Coleopterists Society, The Society for Systematic Biologists, and the Museum of Comparative Zoology (Harvard). I collected beetles and recorded their tapping patterns from several localities across South Africa. I am using these data to determine which species tap, to characterize “songs” across taxa, and to compare variations in tapping patterns between species and genera. Mapping different song types on the phylogeny shows these tapping patterns are not entirely predicted by ancestry. Additionally, in any given locality no two species were found to have the same tap pattern. This suggests that tap patterns may be selected for signal partitioning.

As a postdoctoral researcher in Dr. Smith’s lab, I also contributed to a variety of collaborative projects including an NSF-funded project on the phylogeny of the Pimeliinae subfamily and an AgSEED-funded project on the subtribe Opatrini (Blaptinae). These projects involve reconstructing phylogenies, analyzing biogeographic patterns, performing taxonomic revisions, and producing identification keys. I have led the design of a probe set for non-pimeliine Tenebrionidae. I’ve also generated and assembled a variety of sequence data, including targeted enrichment, transcriptome, and shotgun sequences, for freshly-collected and museum (up to 75 years old) specimens. These assemblies include nuclear protein coding genes, ribosomal genes,

and mitochondrial genomes. Furthermore, I spearheaded the development of a pipeline for processing and analyzing our lab's next-generation sequence data and trained several peers in using the pipeline, as well as basics in bash scripting and Linux coding on Purdue's HPC cluster.

As a professor at DePauw, this summer I conducted a project with four undergraduate students assessing the insect biodiversity at the 500 acre nature park owned by the university. I trained the students in a variety of collecting methods, and in specimen preparation and identification. The students collected and mounted over 4,000 specimens and a significant portion have already been identified to the family level. One student is continuing to work with me this semester, and we are currently working to compare family-level diversity between the woodland and prairie habitats to investigate how habitat diversity may impact overall insect diversity in the park. We also plan to use this data to create a list of species found at the nature park and use aquatic insects to assess aquatic ecosystem health within the park. This research diverges quite a bit from my previous work, but I felt this project was appropriate for introducing undergraduates to entomology research and for utilizing the resources available at DePauw. It has also energized my interest in insect biodiversity research and I am interested in continuing this type of research throughout my career.

Research at Deep Springs College

If I were hired to the Herbert Reich Chair of Natural Science position at Deep Springs, I would continue my research in insect biodiversity of ecosystems with students at Deep Springs. One area of research I am keenly interested in is how insect diversity can be leveraged in sustainable farming practices.

Agriculture is a major cause of habitat loss and declining biodiversity. Looking forward, we need to find solutions that produce the amount of food needed to sustain human populations while avoiding environmental degradation. There is promising research that suggests that maintaining prairie habitats (often in the form of prairie strips) next to and within crop fields can attract insects which provide ecosystem services such as biocontrol and pollination, increasing crop yields. These prairie strips help to mitigate the habitat loss created by agricultural fields, as well as reducing agricultural runoff which negatively impacts ecosystems and human health. However, these studies do not receive as much funding and attention as more traditional pest management and agricultural approaches, and more data is needed to determine how effective prairie habitats can be or how they can be best utilized. Additionally, most of the studies to date focus on row crops rather than specialty crops or multi-crop gardens.

At Deep Springs, I would be able to lay the groundwork for a research program in this area. I would develop a project with students to systematically sample the insect diversity in the college's garden, the habitat directly adjacent to the garden, and other habitats in Deep Springs Valley. Emphasis would be placed on identifying garden pests, natural enemies, and pollinators. My goal would be to provide the college with recommendations on how to attract more pollinators and natural enemies to the garden, based on those found in the area and the specific crops and pests in the garden. If possible, I could also work with the garden manager, students, and others on campus to create a prairie habitat next to the garden and measure how the insect community changes in response to the new habitat. My hope is that I would take the study methods and design I develop at Deep Springs to a permanent academic position where I could establish a long term, replicate-based research program on pocket prairies and community gardens.

In addition to the project outlined above, I would also work with students to develop their own research questions and projects to carry out. This would help to train students in the entire

scientific process, and help them learn how to develop good research questions and methods to actually answer them.

Finally, I believe that small colleges like Deep Springs provide a great opportunity to collaborate with other academics outside my specific field and in areas outside of biology or even the natural sciences. While at Deep Springs, I would seek out collaborations with other faculty members to come up with creative, cross-disciplinary projects that can integrate my research interests and expertise with that of other faculty at the college.