<u>Mary Gates Research Scholarship Application 2012—Wei-Ling (Cherry) Chen</u>

Research Project: Will climate change alter the reproductive success of plants by changing how bees forage?

Climate change is having a huge impact on ecological systems, especially by changing interactions between organisms. For example, earlier spring temperatures have changed environmental cues, and many organisms are advancing the timing of major events in their life such as blooming or mating (known as phenology) (Parmesan and Yohe, 2003). However, variation amongst interacting organisms in their responses to climate change can lead to temporal or spatial mismatch of their phenologies which has repercussions for both parties (Cleland et al 2007).

Plant-pollinator interactions are an example of this. They are very important because mutual dependency is common to many plants and pollinators. In western Washington prairies, bee foraging behavior is critical for plant reproduction, so a shift in the timing of prairie species' blooms could alter which species receives more visits from bees, and thus how much seed each blooming species produces. Bees are the most important insect pollinators in this system. Plants that bloom at the same time can compete for bee visitation (Waser 1978).

I collected preliminary data on two bee species, *Bombus vosesenskii* and *Bombus mixtus,* in summer 2010 to see whether individual bees at Glacial Heritage prairie in Littlerock, WA showed floral constancy (foraged only on one flower species, preventing pollinator competition between species). I followed 153 individuals and investigated their floral constancy by recording the identity of flower species they landed on for their first 20 visits (Fig. 1). Individuals of the same species specialized in different flower species, as has previously been shown in other systems (Bolnick et al 2003). If bees decide to specialize on the flower species they first encounter, the blooming time of prairie flowers at Glacial Heritage could affect their reproductive success.

To gain more comprehensive understanding of how bee foraging behavior interacts with flowering phenology to affect plant reproductive success, I am investigating a specific research question: **"When bees forage on two flower species, does pollinator visitation rate and seed production of each plant species depend on which flower blooms first?"** I plan to perform a greenhouse experiment in which I allow bees to repeatedly forage on 2 flower species, while I manipulate which plant species is presented to the foraging bees first.

I will use seeds I collected in 2011 to grow pots of 2 prairie plant species, *Microseris laciniata* and *Hypochaeris radicata*, in the UW Botany Greenhouse. These species have been successfully grown in the Greenhouse and performed well. Also, they have similar morphology and compete for visitation from the same bees. Instead of using bee species that I observed at the prairie (because it is not possible to get these species), I will use *Bombus impatiens* that is closely related to them and has similar foraging response. I have access to help handling *Bombus impatiens* through Dr. Jeff Riffell's lab.

I will allow three separate bee colonies to forage repeatedly on three plant arrays made up of the two plant species, varying the timing of when each plant species is introduced to the bees to create phenological treatments (Fig. 2). Different colonies of bees will be used for different treatments to avoid distorted results by bees' learning behavior. Overall, bees will have equal time on foraging both species in all treatments, but different degree of overlap between *Microseris laciniata* and *Hypochaeris radicata*.

I will collect data on bee visitation rate and seed production from both plant species in each treatment to see how bee foraging behavior affects plants' reproductive success. My hypothesis is shown in Fig. 3. I predict that seed set for both species will be highest when that species is introduced first, intermediate when the two species are introduced at the same time, and lowest when that species is introduced second, because bees learn to forage first on whatever they meet earliest and be slow to switch resources. However, M. *laciniata* usually receives more visits than *H. radicata* from prairie data, so I predict that bee foraging switch from *M. laciniata* to *H. radicata* will be slower and *M. laciniata* will produce more seed than *H. radicata* in comparable treatments.

This research will provide data on how bee foraging behavior combined with shifting flowering phenology caused by climate change affects reproductive success of plants. The Hille Ris Lambers Lab investigates questions involving how global climate change affects plant communities. My work will contribute to the lab by giving insight into how bee foraging behavior affects different reproductive success. Since *M. laciniata* is a common native plant and *H. radicata* is a common invasive plant in the prairies, my results will also allow me to explore native/invasive plant interactions in the future.

Personal Motivation

Thanks to my father, a doctor in Taiwan who has been giving a free clinic for people in rural areas for years, I grew up with many great chances to explore our Mother Nature as I mingled with local children. Since then, I have fallen in love with the amazing creatures, insects, which play an important role in this ecosystem but are often overlooked by human beings. As I learn more biology, I realize that the destiny of insects and plants are closely connected. As they are at the bottom of food chain, the interactions between plants and insects are extremely important for a sustainable environment.

I began my research experience last summer by working closely with my graduate student mentor, Susan Waters, at Glacial Heritage Preserve in Littlerock, WA. I gained practical skills in problem-solving, experimental setup, and data analysis. Most importantly, I learned that conducting research first hand is the best way to learn science. Through working in the Hille Ris Lambers lab, I have networked with professors and graduate students, and received all kinds of mentoring in ecological research. I am the only undergraduate student actively involved in the Pollination Seminar, a group containing graduate students, postdocs and professors. Having these experiences narrows my interest in ecology and inspires me to turn questions into scientific experiments. Gaining the Mary Gates Scholarship will allow me to focus on my own interest in pursuing further investigation into bee foraging behavior and how it relates to possible changes in communities of flowering plants as a result of climate change.

Future Plans and Benefits of Research Scholarship

To prepare this research project, I already learned a lot by discussing with my mentor and professor to adjust research details, reading papers to gain a better understanding of whole research project, networking with researchers who are experienced with bees and writing a research project proposal. This project will help me gain even more skills to conduct experimental research independently, which will equip me with abilities to succeed in graduate school. I hope to strengthen my problem solving, communication, independent thinking, and other scientific skills helpful for my future career.

Figure 1. Proportions of bee individuals of two species foraging on different floral species.

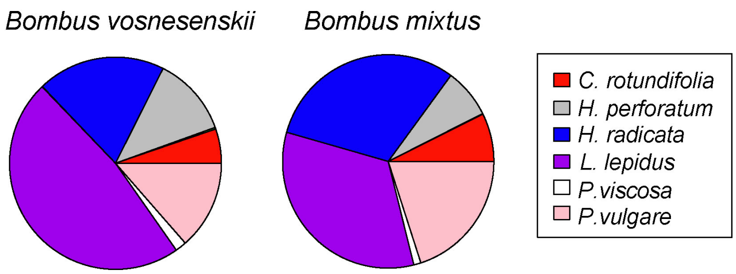
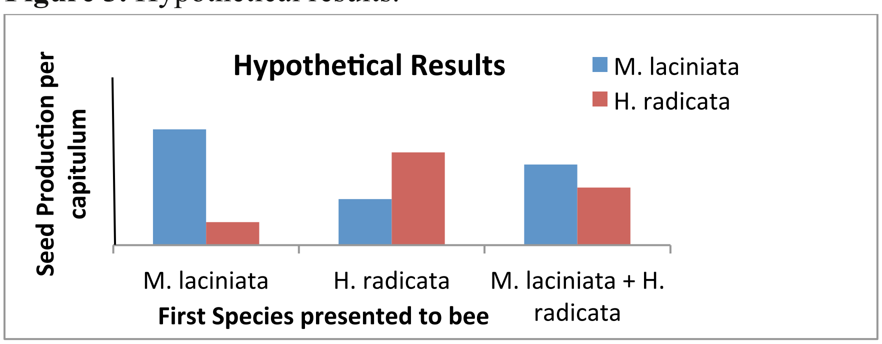


Figure 2. Proposed experimental design: flowers species presented to bees during foraging bouts for three phenological treatments.

	Treatment 1 (bee group 1)	Treatment 2 (bee group 2)	Treatment 3 (bee group 3)
Foraging bout 1	*M. laciniata*	*H. radicata*	*M. laciniata+ H. radicata*
Foraging bout 2	*M. laciniata*	*H. radicata*	*M. laciniata + H. radicata*
Foraging bout 3	*M. laciniata + H. radicata*	*H. radicata + M. laciniata*	*M. laciniata+ H. radicata*
Foraging bout 4	*H. radicata*	*M. laciniata*	
Foraging bout 5	*H. radicata*	*M. laciniata*	

Figure 3. Hypothetical results.



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