An Integral Projection Modeling Approach to Understanding Demographic Effects of Multispecies Mutualisms

Ali Campbell[1,*], Dr. Tom E.X. Miller [1]

[1]*Department of BioSciences, Rice University, Houston, TX 77004*

amc49@rice.edu

Mutualisms are widespread species interactions with diverse and dynamic consequences. They are considered more context dependent than other species interactions, meaning there are many different factors which change the outcomes of interactions between mutualists, including partner diversity. Partner diversity has become a central focus in the field of mutualisms, expanding previous work from primarily pairwise to multispecies mutualisms. It has been shown that pairwise studies are poor predictors of the effects of multispecies mutualistic interactions. The diversity of partners in a multi-species mutualism causes varied demographic effects on the population of the focal mutualist which can be explained by several mechanisms: portfolio effect, complementarity, and sampling effect. This study focused on defensive ant-plant mutualisms. These involve plants which provide food rewards and/or housing to ants, which in turn may defend them from herbivores. While these interactions have been well studied, few have considered how diversity within the ant partner guild affects the overall benefits of mutualism for the plant partner.

I use the plant-ant multispecies mutualism in which, the cactus *Cylindropuntia imbracata* (tree cholla) produce extrafloral nectar and the ants, *Crematogaster opuntiae (Crem.)*, *Liometopum apiculatum (Liom.)*, *Forelius pruinosus (For.)*, and rarer species, provide defense from various herbivores and seed predators. I used 18 years of data collected from plant demographic censuses, which includes data such as size, survival, reproductive status, flowers produced, and ant partner for all plants in 8 30x30 m plots at the Sevilleta National Wildlife Refuge in central New Mexico. With this data I parameterize a series of Bayesian hierarchical generalized linear vital rate models to determine the impacts of different partners on the focal mutualists. I found that different ant partners had different impacts on the vital rates of the tree cholla. Specifically, *Crem.* tended plants had advantages in both growth and survival when small, and large *Liom.* tended plants had floral viability advantages. With these models I constructed an Integral Projection Model in which I could vary the presence of each partner, creating different "diversity scenarios", to determine under which diversity scenario the focal mutualist experienced the highest plant fitness, and which mechanism(s) may explain the effects of partner diversity. I found that the observed scenario (all possible ants are present) lead to the highest fitness for the tree cholla, indicating that partner diversity is beneficial in this system. Results further suggest that diversity benefits in this system are driven by complementarity , meaning different partners offer different benefits leading to synergistic benefits for the tree cholla associating with multiple partners. This study highlights how partner diversity can increase the overall benefits a focal mutualist receives. It also highlights the importance of a mechanistic understanding to explain the benefits of this diversity across systems.