Pollination Preferences of *Geranium richardsonii* Between Bee and Fly Species at High and Low Elevations.

Student: Sara Cooley

Mentor: Ruben Alarcon, PhD

Abstract

Geranium richardsonii was studied at three different elevations to determine if there was a change in the type of pollinator species that visited it. The purpose of this experiment was to test the hypothesis that flies are more abundant at higher elevations and replace bee species found at lower observation sites. Transects at Virginia Basin (3,438m), Avery Picnic (2,969m), and Ohio Pass (2,790m) used for a pollination network study from 2016 to 2021 were divided into one by two meter segments and were monitored for floral visitors. Visitors being determined as insects that visited *Geranium richardsonii* were collected and later identified as bees, flies and other insects. Although flower abundance of *Geranium richardsonii* varied between sites, there was no significant difference in the number of bee or fly visits to flowers. The results of this study show that bee and fly abundance at the elevations tested is comparable despite a difference in site flower abundance. To further this experiment in the future a wider elevational gradient could be tested using a more direct sampling method. Sites at higher and lower elevations than the ones studied would create a better selection of sample sites, while focusing on *Geranium richardsonii* and not a plant network would aid data collection.

Introduction

As the snow packs melt at the beginning of summer, plants begin to emerge along with bees, flies, and other pollinator species. *Geranium richardsonii* is a flowering plant grown in subalpine and foothill areas with snowmelt (Nagy 2019), and are native to moderately disturbed habitats on open meadow and aspen understory (Antecon 2016). This plant has been shown to be pollinated by bee species at a lower elevation of 1,854 meters (Green 1978) but has been found to grow in higher subalpine meadows. There have been few studies on the pollination of *Geranium*

richardsonii at higher elevation to see if it is predominantly visited by bees. Bees are energy-demanding insects that expend large amounts of energy through continuous foraging and provisioning to nests (Kearns 1992) expending much of the energy they would need to help them thrive in such harsh environments. Flies tend to have higher rates of survival at higher elevations and their success at high elevations may be related to the presence of favorable larval habitat, and their lower energy requirements in comparison to bees (Kearns 1992). Taking into consideration favorable conditions for fly species at high elevation relative to bees, I studied the visitors of *Geranium richardsonii* at sites from different elevations. Using the knowledge that the conspicuousness of flies at high elevations appears to be due to decreased numbers of other insect orders (Kearns 1992) I hypothesized that mostly flies would visit *Geranium richardsonii* at higher elevations due to the harsh environments while mostly bees would visit flowers at lower elevations. However if bees are as equally abundant visitors at higher elevation, this would reject my hypothesis. This study also provides an updated account of the types of pollinators of *Geranium richardsonii* while also giving an insight to pollinator variation at different elevations.

Methods

The study sites were between 2,790 and 3,438 meters in elevation located near Gothic, Colorado (figure 1). This included wet meadows of the Ohio Pass at 2,790 meters, Avery Picnic at 2,969 meters, to the subalpine meadows of Virginia Basin at 3,439 meters. Each of the three sites had between four and six transects separated into five to ten, one by two meter segments depending on overall length. Transect length varied between ten to twenty meters depending on location and sites were monitored between 2016 to 2021. Each site was sampled one to two times a week beginning in late June through early August. Surveys usually took place between 10:00 A.M. and

3:00 P.M. depending on favorable weather conditions. Sites were surveyed by one to four people who observed segments in a randomized order for three to five minutes per segment, with pollinator visits only recorded when an insect landed on the reproductive parts of a plant. Pollinators were captured by netting and identifiable insects such as bumblebees, *Osmia* and butterflies were released after being recorded, while other insects were placed in vials with labels to identify date, observer, and segment of capture. Insects were later sorted and identified into taxonomic groups. The number of open *Geranium richardsonii* flowers along each transect were also recorded on a weekly basis to estimate floral abundance. Floral abundance was recorded by examining each segment of each transect on days of observation and recording of all open pollen producing flowers.

Statistical Analysis

I used Analystat Version 1.6.50 to perform a one-way Anova and a Tukey post hoc test to compare the floral abundance of *Geranium richardsonii* between Virginia Basin 3,439 meters, Avery Picnic 2,969 meters and Ohio Pass 2,790 meters. I also used several Anova to compare the mean number of bee visits per flower per site and the mean number of fly visits per flower between sites for the days that visits to *Geranium richardsonii* were recorded.

Results

At Virginia Basin 3,438 meters and Avery Picnic 2,790 meters, there were thirteen days of observation where pollinators were observed visiting *Geranium richardsonii,* but only five days of observation where visitors were observed at Ohio Pass. *Geranium richardsonii* had a mean flower abundance of 16.23 (SE = 3.58) at Virginia Basin, 30.38 (SE= 6.22) at Avery Picnic, and

9.6 (SE = 2.49) at Ohio Pass (figure 2). There was a significant difference in the flower abundance of *Geranium richardsonii* across sites (F= 3.4975, df = 2, 28, p = 0.0441). Post-hoc tests suggest that Avery Picnic had more *Geranium richardsonii* flowers than Ohio Pass (Tukey HSD: p = 0.0746). *Geranium richardsonii* received a mean number of 0.1798 (SE = 0.1017) bee visits per flower at Virginia Basin, 0.0953 (SE = 0.0361) bee visits per flower at Avery Picnic and 0.3683 (SE = 0.0668) bee visits per flower at Ohio Pass (figure 3). There was no significant difference in the mean number of bee visits per flower across the sites (F= 1.8439, df = 2, 28, p = 0.1769). The mean number of fly visits per flower was 0.19 (SE 0.0597) at Virginia Basin, 0.2479 (SE = 0.1095) at Avery Picnic and 0.1971 (SE 0.0584) at Ohio Pass (figure 4). There was no significant difference in the mean number of fly visits per flower to *Geranium richardsonii* among sites (F= 0.128, df = 2, 28, p = 0.8804).

Discussion

Does the overall percentage of fly pollination increase at higher elevations? Keeping in mind that the conspicuousness of flies at high elevations appears to be due to decreased numbers of other insect orders (Kearns 1992), fly pollination does not increase at higher elevations. Though flies tend to have higher rates of survival at higher elevations (Kerns 1992) and higher elevations equate to harsher, colder environments, we still see a distinct amount of fly and bee pollination activity at all sites. Though it has been shown bee species pollinate *Geranium richardsonii* at lower elevations(Green 1978) there is nothing in our data to suggest that bees make up any lesser part of pollination interactions with *Geranium richardsonii* at any elevation. Using the research that was conducted in 2021 combined with the research from the network study ranging back from 2016 to 2021 there was no difference in the mean visits per flower for both bees and flies.

There was however, a significant difference between the floral abundance on the middle site Avery Picnic, and the low site Ohio Pass, but this did not translate into a difference in visitation. This may be explained by our sample size being too low as the data used totaled 13 observation days for Avery Picnic and Virginia Basin, and only 5 observation days for Ohio Pass. However, the results could also be showing that there is not a significant elevation gradient to show any real change in the pollination habits of either bee or fly species. This study could be improved by continuing research using a focused study on *Geranium richardsonii* and a wider elevation gradient at a minimum of 1,000 meters. This study caused no long term harm to the study areas, though trampling of vegetation around transects had a short term impact on the location as well as the slight decrease in the insect pollination population due to netting and collection. Neither of these caused long term harm to the area. All sites at proposed locations were being used for similar research using similar methods eliminating the potential for conflict.

Acknowledgments

I would like to thank my mentor Dr. Ruben Alarcon for his guidance and support, and Kaysee Arrowsmith and the Brosi Lab for access to their network data and their assistance with my project.

Literature Cited

Antecon, S. (2016) Sex ratio and reproductive success along elevational gradients of gynodioecious populations of *Geranium richardsonii.* Part-time Independent Research in Field Ecology Course Summer 2016, 1-14.

Green, B. (1978) Comparative Ecology of *Geranium richardsonii* and Geranium nervosum. Bulletin of the Terry Botanical Club, 105(2), 108-113.

Kearns, C. (1992) Anthophilous Fly Distribution Across an Elevation Gradient. The American Midland Naturalist, Jan., 1992, 127(1), 172-182.

Nagy, L. (2019) Rocky Mountain Wildflowers Field Guide Expanded 3rd Edition. High Country Artworks, Fairplay, CO. 37

Figure 1

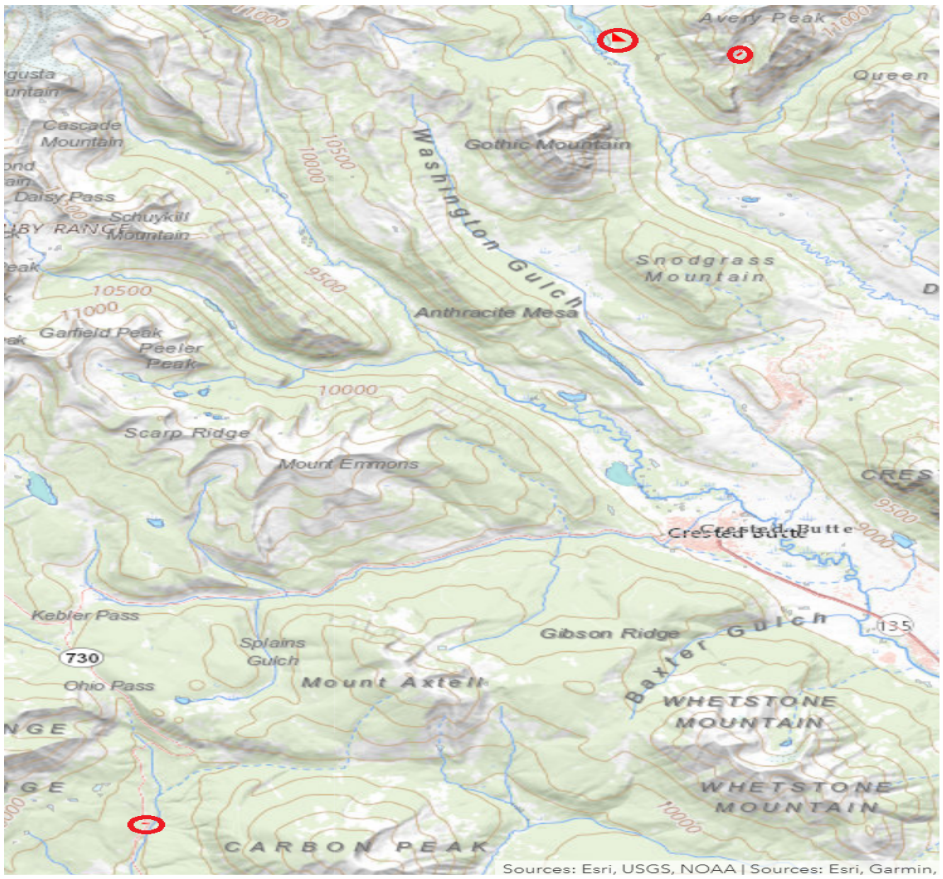

Figure 1, Site map showing all 3 elevation sites

Figure 2

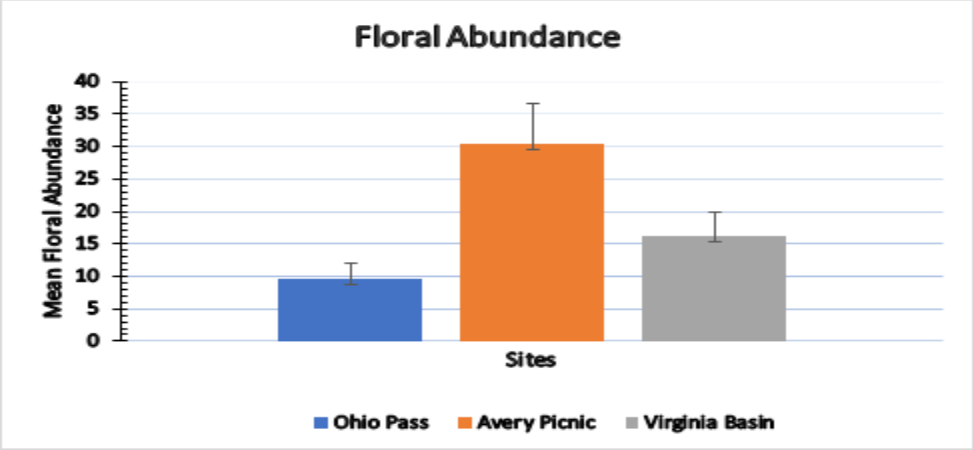

Figure 2, Mean (+SE) floral abundance of *Geranium richardsonii* at all three sites. There was a significant difference in the abundance between Avery Picnic and Ohio Pass.

Figure 3

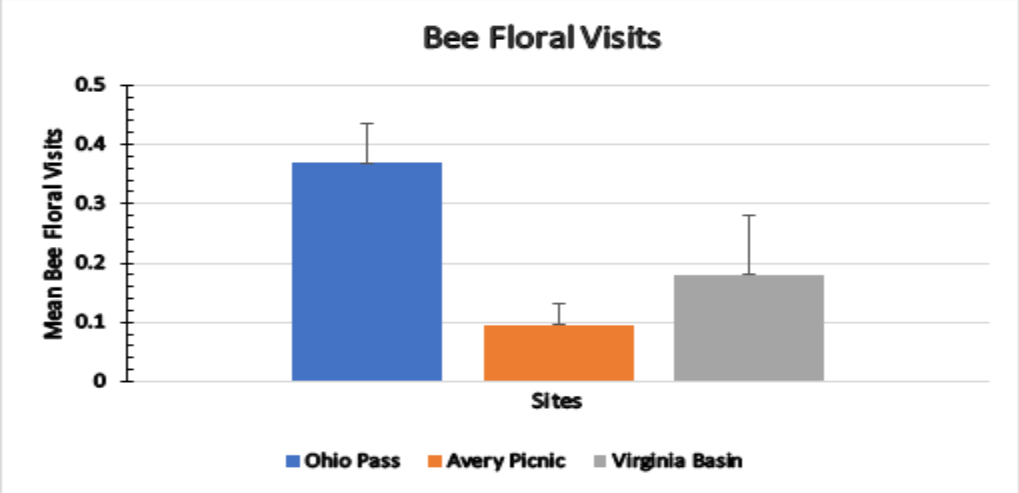

Figure 3. Mean(+SE) bees visits per flower at all three sites.

Figure 4

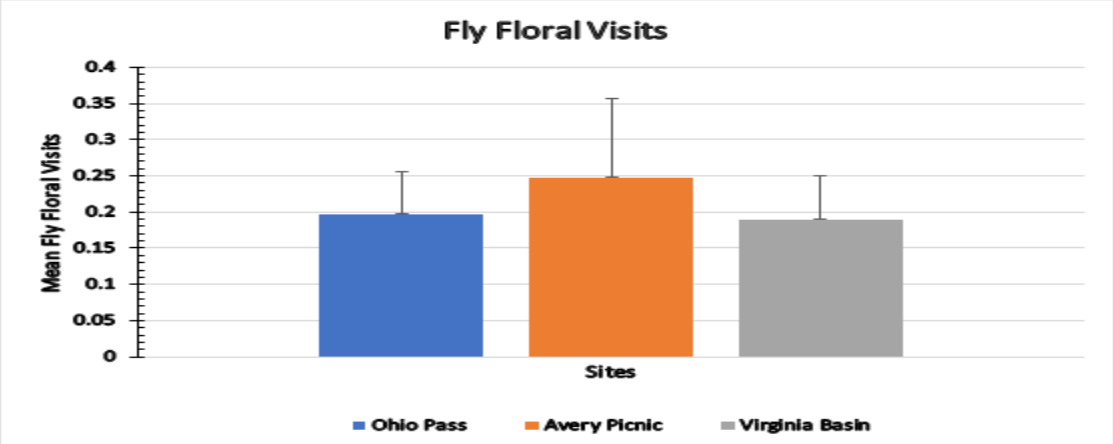

Figure 4. Mean (+SE) fly per flower at all three sites.