

Pollination Syndrome variance among foraging bumblebee species in Gothic Colorado

Stella Lindbergh 2024

Introduction ↴

Pollinators are vital parts of terrestrial ecosystems (Raiol et al., 2021) as they are a primary consumer in the trophic pyramid; they ensure the continued survivorship of the earth's plants and animals by providing pollination services and food. One of these essential pollinators is the bumblebee or *Bombus* spp. Bumblebee pollinators are 2-4 times more effective at pollinating than their counterparts, as they start pollinating much earlier in the day than other species and work longer hours (Mcfarlane, 2011). Another reason for increased bumblebee efficiency during pollination practices is their ability to carry out "buzz pollination" behavior, meaning that when they pollinate a flower, the vibrations they make can knock pollen out of the plant's anthers, which fertilizes the plant, allowing it to produce seeds and fruit quicker than when pollinated by non-buzz pollinating species (Vallejo-Marin, 2018). Bumblebees also have "pollen baskets" on their back legs, which allows them to scoop up more pollen from flowers and bring it to other flowers or back to their nest.

Pollinators prefer certain plants and flowers while foraging, which often depends on flower shape and color (Reverte et al., 2016). These seemingly innate preferences are often known as pollination syndromes. I will look at the concept of "Pollination Syndrome," which is a suite of floral traits associated with attracting a specific group of pollinators (Hermann & Kuhlemeier, 2011). Pollination syndromes refer to the co-evolved mutualistic relationships

between pollinator species and their preferred flowers. Pollination syndromes depend on both the morphological characteristics of flowers, including color, flower shape, and scent, as well as the morphological characteristics of a pollinator-like tongue length. The complementary morphology between plant and pollinator is highly beneficial to both parties involved as the pollinator benefits from receiving high amounts of pollen and nectar while the plant species is more successfully aided in their reproductive process through the visiting pollinator. This is due to the existence of pollinator-mediated selection, or the evolutionary process of flowers that is favored by pollinators' foraging behaviors. (Cruzan 2018). While these "syndromes" are thought to be hard-wired into the species they present in, flower color preference can often depend on environmental conditions such as selective pressure, pollinator-driven adaptation, and geographical distribution of pollinators and their available resources.

Further, pollinator foraging preferences are limited by the amount of floral resources available in their location at a given time and season. Therefore, a known pollination syndrome might not always be present in its designated species when studying the individual traits of pollinators and their relationships with the flowers and plants in their environment. When a pollinator chooses to visit a flower of one color, it takes time away from visiting a flower of another color in the same area. This could alter the latter floral species' reproductive success and influence the plants' abundance and diversity in that environment. Bumblebees, which I will be focusing on in this study, are known to be overwhelmingly generalist pollinators, meaning they can give and receive food and nectar from a wide variety of flowers, including common crops. Previous studies have also pointed out that while bumblebees are more generalist, they can allocate foraging efforts to plants in their niche; in other environments, they have been observed to prefer flowers with blue and green pigments. (Balamurali1 et al. 2018).

Research Questions and Hypotheses ↴

Pollination syndromes vary among species, as different pollinators live all over the world in environments that, over evolutionary time, possess different floral abundance and diversity. While there are expected differences amongst pollination syndromes between mammal pollinators like bats and insect pollinators like bumblebees, smaller-scale differences exist between different members of the same animal kingdom. I will focus on these smaller-scale differences in my project, focusing exclusively on bumblebees found in sub-alpine meadows in Colorado. This project aims to (1) determine if local Rocky Mountain bumblebee species prefer flowers with cooler or warmer pigments and (2) whether Rocky Mountain bumblebees exhibit similar or different pollination syndromes among species. I hypothesize that Rocky Mountain bumblebees will demonstrate preferences for purple flower species such as Delphinium and Lupine since they contain the pigments closest to blue and green, which bees have been known to prefer in other environments. In contrast, my second hypothesis is that Rocky Mountain bumblebees will demonstrate a preference for white and yellow flowers since they are more abundant in the surrounding areas and my field sites. My third hypothesis is that Rocky Mountain bumbles will display no preference for specific flower colors.

Methods ↴

Field Sites ↴

To conduct this project, I worked across one field site, Dan Bench Research Meadow. In addition to collecting data at this field site, my mentor and I joined other Brosi lab teams at their field sites to practice identifying local bumblebees, as there were many bumblebee fly mimics in the surrounding area.

Specific Methodology ↴

To conduct my research, I looked at five local bumblebee species: *Bombus bifarius*, *Bombus californicus*, *Bombus nevedensis*, *Bombus flavifrons*, and *Bombus appositus* and measured foraging rate and flower abundance. Bumblebee preference was measured as foraging rate per unit flower abundance; I conducted a statistical ANOVA test to determine whether pollination preference correlates with flower color. To calculate the foraging rates of the bumblebees, we tracked them by foot and voice recorded: bumblebee ID, patch number, flower species, how many flowers it visited in that patch, how many plants it visited at that patch and when it left that patch either to go to another patch or to leave completely. Numbered flags were placed at every patch it visited. Then, we used the flags to record the bumblebee's multiple locations with the Trimble DA2 GPS unit to match the foraging rate with flower abundance in the images collected by the drone. My mentor conducted an aerial survey with a drone to measure flower abundance. Using GPS data, we matched the coordinates of the patch the bumblebee visited to the coordinates of the images taken by the drone and individually counted all the flowers within a 1-meter radius of the patch where the bumblebee was located. We additionally counted three transects of flowers on the ground where our bees visited to evaluate the efficacy of counting them in the images from the drone. Data was collected in Google Sheets and Label Studio and analyzed and graphed using Rstudio.

Calculating Floral Abundance

As previously stated, preference was measured by dividing the foraging rate by flower abundance. We developed two hypotheses for quantifying flower abundance: One was that bees see “blobs” of color or a mix of individual flowers and flowering plant stalks, similar to what the drone images can distinguish, so they see a plant of delphinium as equivalent to a single flower

of potentilla. The second was that bees can distinguish the individual flowers in a patch they are foraging in.

Map of the Dan Bench Field Site:



Results/Graphs ▾

Figure 1 (Hypothesis 1)

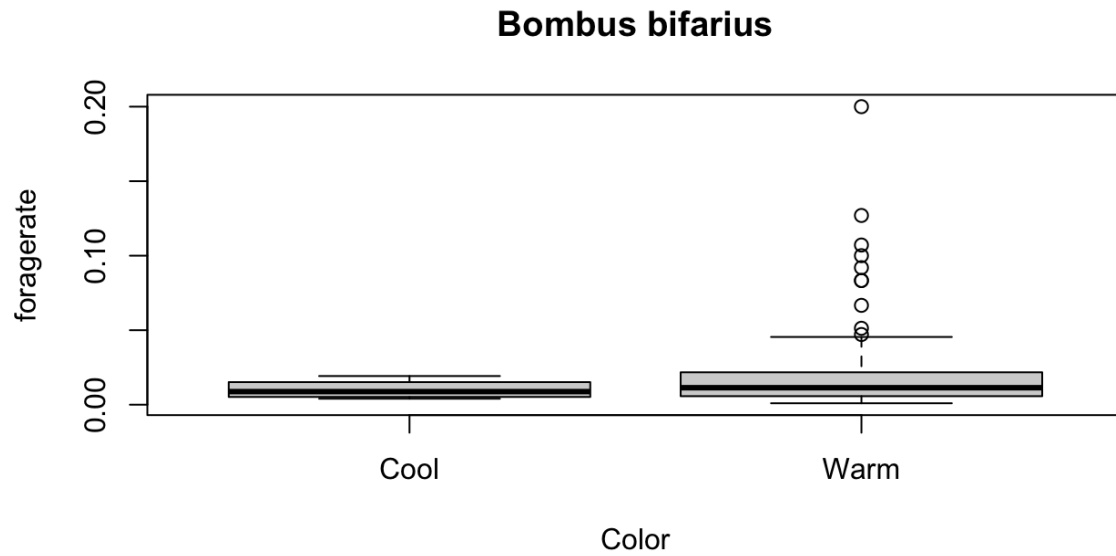


Figure 1: A boxplot showing the forage rate on the “blob”s: a mix of plants and flowers of *Bombus bifarius* on differently pigmented plants.

Figure 2 (Hypothesis 1)

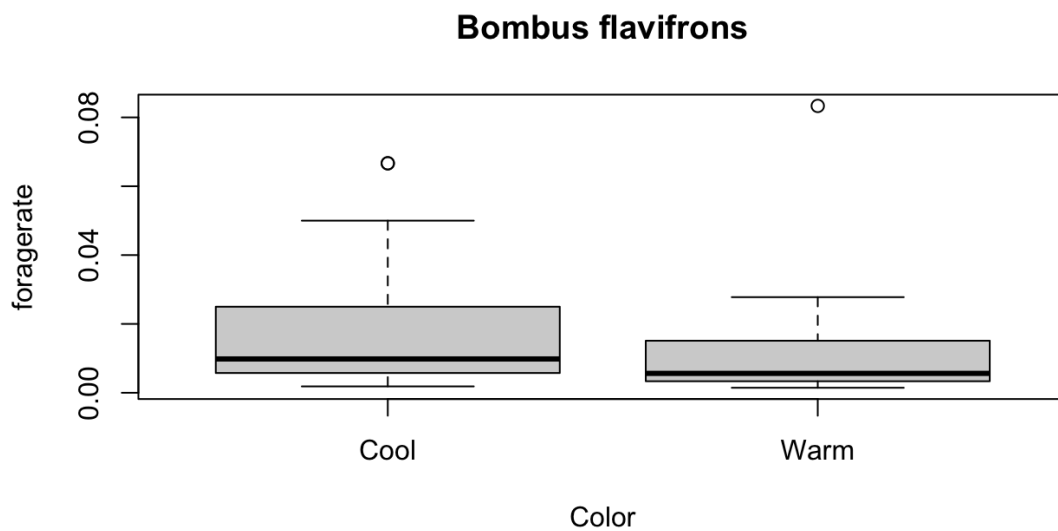


Figure 2: A boxplot showing the forage rate on the “blob”s: a mix of plants, flowers, of *Bombus flavifrons* on differently pigmented plats

Figure 3 (Hypothesis 1)

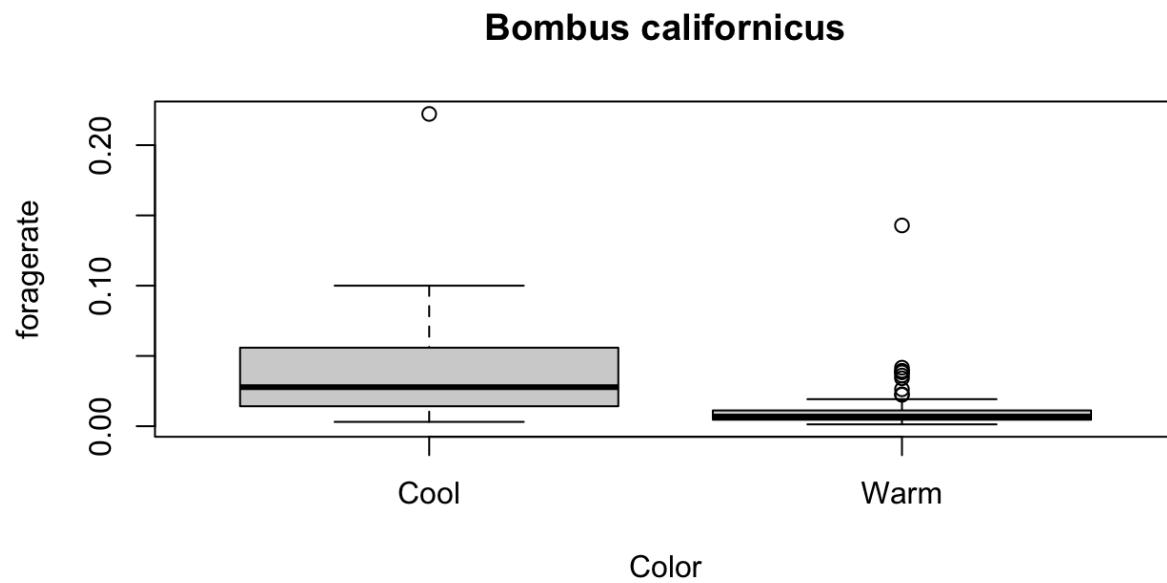


Figure 3: A boxplot showing the forage rate on the “blob”s: a mix of plants, flowers, of *Bombus californicus* on differently pigmented plants

Figure 4 (Hypothesis 1)

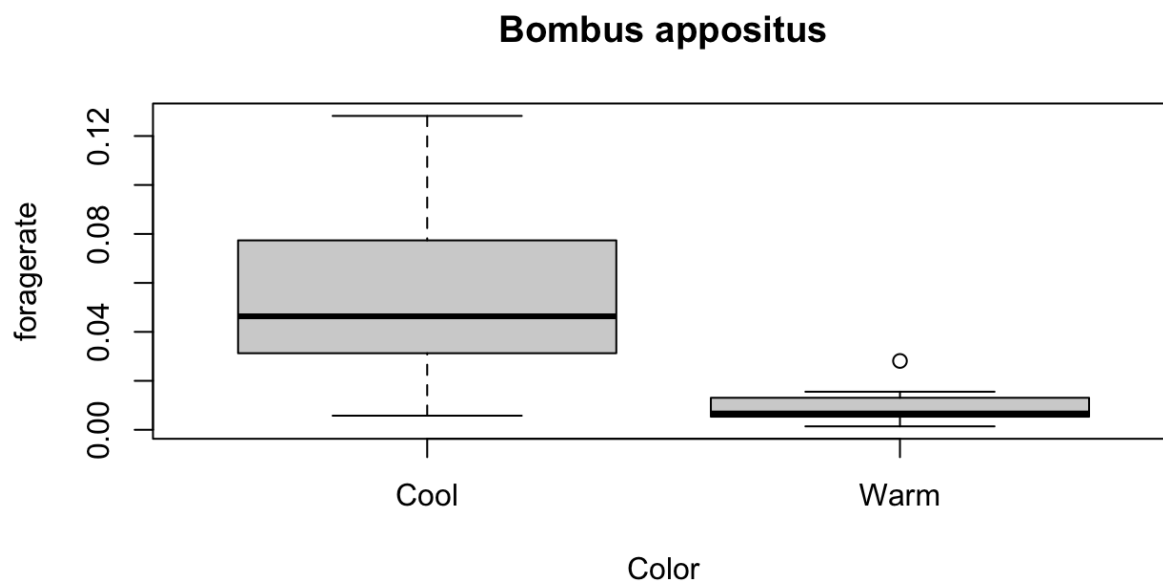


Figure 4: A boxplot showing the forage rate on the “blob”s: a mix of plants, flowers, of *Bombus appositus* on differently pigmented plants.

Figure 5 (Hypothesis 2)

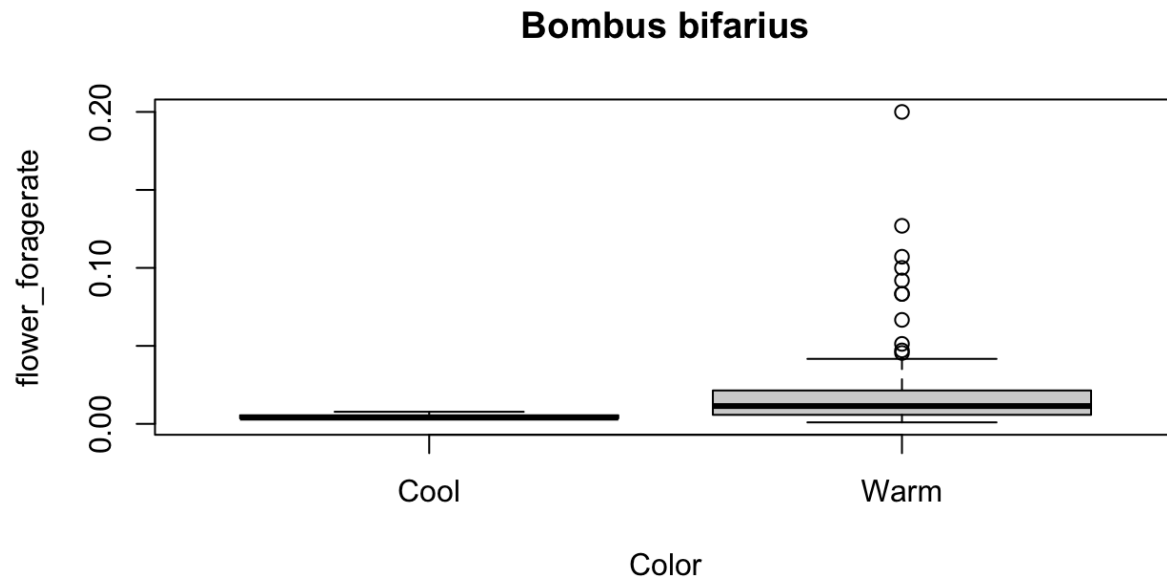


Figure 5: A boxplot showing the flower forage rate of *Bombus bifarius* on differently pigmented plants within foraging patches.

Figure 6 (Hypothesis 2)

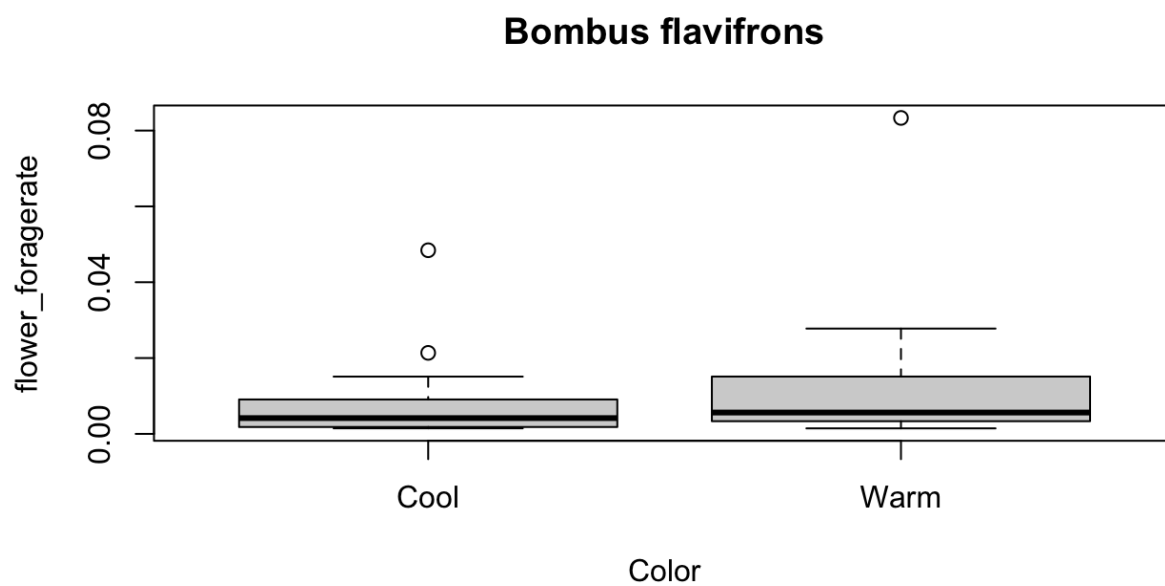


Figure 6: A boxplot showing the flower forage rate of *Bombus flavifrons* on differently pigmented plants within foraging patches.

Figure 7 (Hypothesis 2)

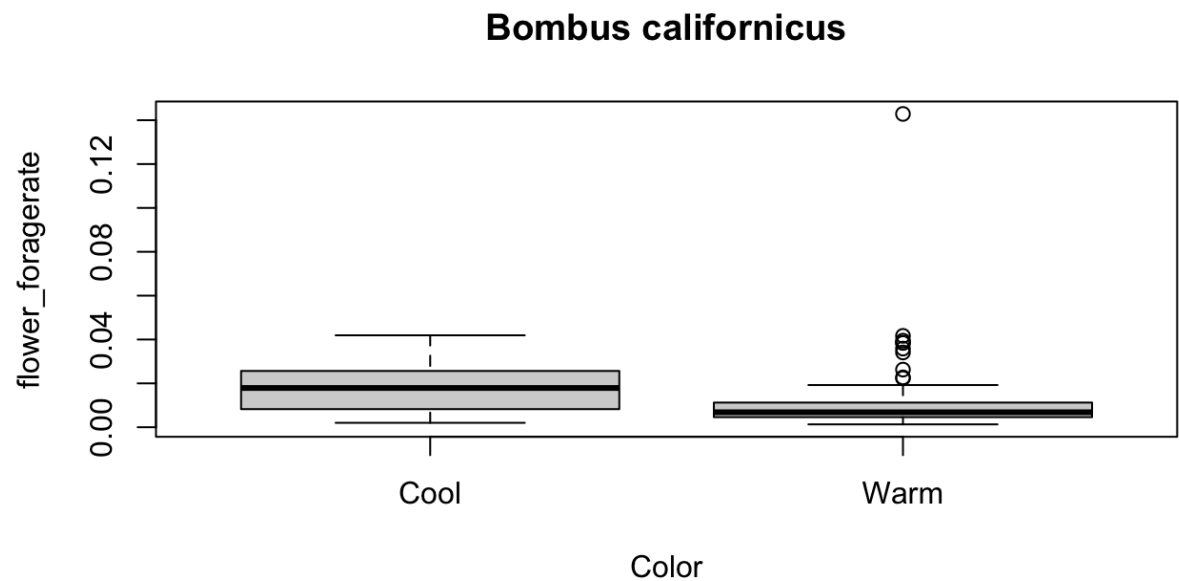


Figure 7: A boxplot showing the flower forage rate of *Bombus californicus* on differently pigmented plants within foraging patches.

Figure 8 (Hypothesis 2)

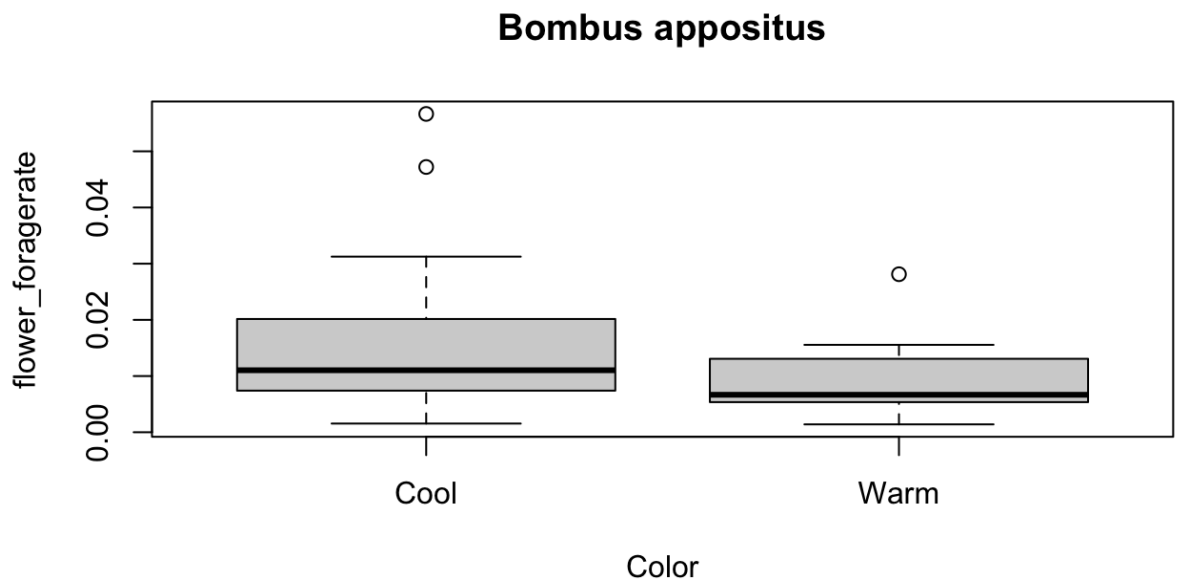


Figure 8: A boxplot showing the flower forage rate of *Bombus appositus* on differently pigmented plants within foraging patches.

Discussion ↴

My initial hypothesis was that bumblebees would exhibit a preference for purple and blue flowers due to previously researched foraging patterns in different environments. Before the analysis was run, we came up with two ways to measure floral abundance: 1: Bees are seeing blobs of color similar to what the drone images of their foraging patches can distinguish. And 2: Bees always see individual flowers in every patch. When creating boxplots in R that display “blob” forage rate (the number of plant visits) against color (warm, cool, white), among the five bee species analyzed, two demonstrated a significant color preference. *Bombus californicus* and *Bombus appositus* (P-values < 0.0), it was found that *Bombus californicus* and *Bombus appositus* demonstrate a foraging preference for cooler-colored flowers over warmer colors. It is also worth noting that *Bombus nevadensis* was only ever found pollinating cool-toned flowers like *Delphinium Barbeyi* that I could not conduct a statistical analysis for this species since there were no other color flowers within their foraging patches to compare to. My second hypothesis that bees see the individual flowers in every patch they visit at all times was slightly supported by an analysis that showed a slight but non-significant correlation between individual flower forage rate and color preference (warm, cool, white) in *Bombus californicus* (p-value < 0.1) and *Bombus appositus* (p-value 0.143).

Conclusion ↴

It was found that across the five bee species, I studied, there was a significant color preference among individuals of *Bombus californicus* and *Bombus appositus* who both demonstrated a statistically significant preference for cooler-pigmented flowers like *Delphinium barbeyi* and *Lupine* spp. (p-values: < 0.1 and 0.143) than warmer-colored flowers like *Potentilla*

pulcherima and Pyrrocoma crocea. This analysis suggests two conclusions: though this study yielded significance amongst two of the five species, there are reasons why significant preference was not present in the other three. Foraging preference could be flexible and based on resource availability, or pollinator syndromes are driven by factors that were not examined in this study. For example, another reason we could see more bumblebees demonstrating preferences for cool colors might depend on bumblebee morphology, as not all bumblebee species have the same morphology. One of these main differences amongst species is tongue length. It is plausible that the bees “preferring” cool plants are more frequently visiting flowers with deeper nectar sources since their tongues can reach inside these flowers easier than when foraging on plants with surface-level morphology. Further research that could be done would include tongue length measurements across the different bee species to see if there is a pattern in the kinds of flower bees with longer or shorter tongues visiting. Directly factoring floral morphology into further replicates of this experiment could also lead to interesting patterns. The foraging rates and patterns of bumblebee species are important to study so we can learn more about insect behavior and further examine the biotic and abiotic factors that can alter these behavioral patterns in one of the terrestrial ecosystems’ keystone species. As if foraging preferences are flexible, it may suggest a greater adaptability to climate change.

Acknowledgments

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