Population Sex Ratio of Coyote Brush (*Baccharis pilularis*) in Stebbins Cold Canyon Reserve

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Writer's Comment: UC Davis' Stebbins Cold Canyon Reserve is home to a classic Californian chaparral landscape. One of the dominant plants found there is Baccharis pilularis*, or coyote brush, named for the fluffy white flowers that look like a coyote's tail when in full bloom. Since these plants have male and female flowers on separate individuals, the stability of the population depends on maintaining a balance between the sexes. These plants are also staples in studying pollinator ecology because they bloom through fall and are one of the only pollen and nectar sources for late-season pollinators. With my major in Plant Biology and minor in Ecology, I plan to study pollinator ecology and to develop strategies to sustain native bee and butterfly populations using native Californian plants like* B. pilularis*. Studying these plants and the role they play in the natural environment is the first step to creating sustainable habitats in our own backyards.*

Instructor's Comment: In my Plant Ecology course, we get out of the classroom to provide hands-on experience with the ecological concepts and processes we discuss in lecture. To do this, we visit local field sites to learn about local plant species, habitats, and ecosystems, as well as to ask questions and make observations about the real-world ecology important to these places. As teams, students collect data in the field to address ecological questions and test hypotheses, then report the results as a scientific paper. For this assignment, Lauren Glevanik writes about one of the studies the class conducted in Fall 2019. Here, she studied a locally common shrub, coyote bush (Baccharis pilularis)*, a species with distinct male and female plants. That is, some individuals produce female flowers and other individuals produce male flowers. This sexual strategy is somewhat rare in flowering plants, and the ratio of male and female individuals has important consequences*

for reproduction and changes in population size over time. In this study, Lauren asks whether the ratio is what would be expected to be optimal for the population, and whether male or female plants differed in size. Interestingly, many of the plants were difficult to sex because the bloom was delayed and many flowers had not fully matured at that time in the season. This was an unexpected lesson in doing real-world field ecology, particularly in a variable Mediterranean climate, where sometimes timing is difficult and patterns can be hard to predict. Lauren nicely describes these questions, the challenges with making conclusions given the uncertainty in the data, and other factors that may be influencing these populations.

—Jennifer R. Gremer, Department of Evolution and Ecology

Introduction

Baccharis pilularis, or coyote brush, is a dioecious perennial shrub native to the western coast of North America (Smither-Kopperl 2016). As a dioecious plant, the male and female reproductive organs are located on separate individuals (Barrett 2010). These plants rely on both wind and insects for pollination since the pollen is located on a separate individual than the ovaries (Barrett 2010). Maintaining a balanced ratio of male to female individuals is important for the population to survive and reproduce. The population's health further impacts species composition and biodiversity of the larger ecosystem, including key pollinator species that rely on these plants as late-season sources of pollen and nectar. This study aimed to determine if the sex ratio of *Baccharus pilularis* (*B. pilularis*) as of October 5-6, 2019 approached the optimal sex ratio of 50% male and 50% female individuals. A secondary goal of this study was to determine if the sexes differed in size, since plant height and width may affect how easily pollen is dispersed. To investigate these questions, we recorded and analyzed the height, width, and sex of each occurrence of *B. pilularis* along a 1-mile segment of the Blue Ridge Trail.

Methods

Over the period of October 5-6, 2019, two teams of students measured height, width, and sex of each *B. pilularis* found along the Stebbins Cold Canyon Blue Ridge Trail from approximately the

1-mile mark to the trailhead. The height and width of each individual was measured in meters using transect tapes. The sex of the plant was determined by observing the flowers or by breaking open immature flower buds to look for pollen. These values were recorded for every *B. pilularis* found along the trail that was accessible without encountering poison oak.

Results

A total of 110 individuals were surveyed. However, as to whether the sex ratio approaches the optimal ratio, the overall results of the data collected are inconclusive. ***Table 1*** reports the numbers of individuals of each sex surveyed. Only 21 plants were conclusively identified as female (7) or male (14). Of the remaining plants, 59 had undeveloped buds and 30 showed no buds at all. While we did find a male to female ratio of 2:1 in the small subset of identified plants, we cannot conclude this ratio is true for the entire population. Nearly 81% of surveyed individuals could not be determined as male or female. Because of the small sample size of the identifiable individuals, this data is incomplete and the true sex ratio of the *B. pilularis* population cannot be determined at this time.

While the sex ratio cannot be concluded from the data collected, there was a large enough sample size to analyze the height and width of each individual of the population. Statistical analysis of the measurements for the female, male, and unknown *B. pilularis* individuals showed these groups did not significantly differ in size ($p = 0.95$ for width and $p = 0.18$ for height, both of which fail to reject the null hypothesis that there is no difference in size). ***Figure 1*** shows the widths of developed, undeveloped, and non-budding plants. The mean widths of each of these three categories are not different enough to conclude there is any difference between the heights of these groups. Similarly, ***Figure 2*** depicts the mean heights for flowering, budding, and non-budding plants with no significant difference among these groups ($p = 0.18$, failing to reject the null hypothesis that there is no significant difference).

Discussion

While our sample size of male and female plants is too small to determine the true sex ratio of the population, we do have sufficient data to compare plant sizes. Between plants with developed and undeveloped

buds, and even between female and male plants in our small sample size, there was no significant difference in height or width. These results suggest plant size and plant sex are not correlated.

The majority of plants we observed were unidentifiable because the flower buds were immature or not yet present. We only identified the sexes of 21 plants: 7 female and 14 male, with 89 plants of unknown sex. Due to the very small sample size of plants with known sexes, we cannot conclude this ratio applies to the entire population. While we were measuring plants and recording the sex, many of the assigned male or female plants were identified by breaking open immature flower buds and checking for the presence of pollen and anthers. Even the identified plants were not fully in bloom yet and we never found a plant that was fully flowering.

Several environmental factors may have affected these results. The most prominent source of error is the delayed bloom time of *B. pilularis*. Typically, coyote brush blooms between August and October as a late-season source of pollen and nectar for pollinators (Montalvo 2010). This year, *B. pilularis* did not bloom until very late October. One factor that may affect flowering time is deviation from the typical climate, such as the unusually cold and late spring this year. Altered bloom time may also be a long-term consequence of the 2009-2016 drought (Cho 2017).

Further study is needed to determine if there is a true 1:1 sex ratio within the Stebbins population of *B. pilularis*. On October 20, 2019 I returned to Stebbins Cold Canyon Reserve to hike the Blue Ridge and Homestead Trail to go birdwatching. Since most of the Baccharis was in full bloom, I decided to repeat the survey of the sexes. I hiked the entire 5.1 mile loop starting on the Blue Ridge side and photographed every *B. pilularis* I encountered on the trail. I found 140 individuals. Of those, 10 were undeveloped, 64 were male, and 66 were female. From those individuals alone, I found a nearly 1:1 sex ratio (49.2% male and 50.8% female of the identified plants). Only two weeks after our initial survey, nearly all the individuals I encountered were blooming and I found a ratio closer to our initial prediction.

From a genetic standpoint, there should be a 1:1 sex ratio in a population with two sexes since males make half of their gametes with X chromosomes and half with Y chromosomes (Barrett 2010). This ratio should be maintained through the mechanism of gamete formation according to the Law of Segregation and the Law of Independent

Assortment when the sex chromosomes segregate into different gametes (Barrett 2010). The reproductive success of dioecious gametically limited individuals depends on the proximity of a plant of the opposite sex and a successful pollination strategy (Barrett 2010). It makes logical sense for there to be a balance of sexes based solely on the segregation of sex chromosomes. If there were not a 1:1 ratio, it would suggest some sort of bias after germination (Barrett 2010).

Conclusion

Great uncertainty in identifying the sexes of *B. pilularis* was a major challenge in this study that led to inconclusive results. In previous years, this study (conducted at the same time of year) yielded stronger results and nearly all of the plants were easily categorized as male or female. Since the data from this year is insufficient, other factors must have affected blooming time. When the population sex ratio was measured later in the season, the results approached the expected 1:1 ratio. These results demonstrate the Law of Independent Assortment and the Law of Segregation at work in the natural distribution of gametically limited individuals. Future studies should consider bloom time of separate male and female individuals as another factor of reproductive success in dioecious plants.

Tables and Figures

Baccharis	n	mean height (m)	mean width (m)
Female	7	1.61	1.656
Male	14	1.625	1.616
None	30	1.36	1.49
Undeveloped	59	1.62	1.62

Table 1. Mean height and width of male, female, and sex-unknown B. pilularis *individuals.*

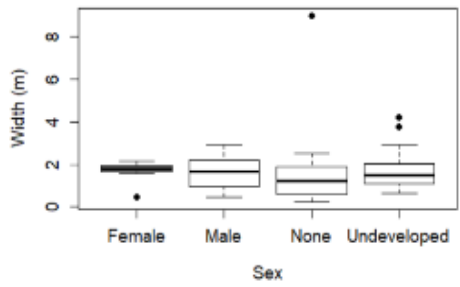

Figure 1. Boxplot of width for male, female, and sex-unknown B. pilularis.

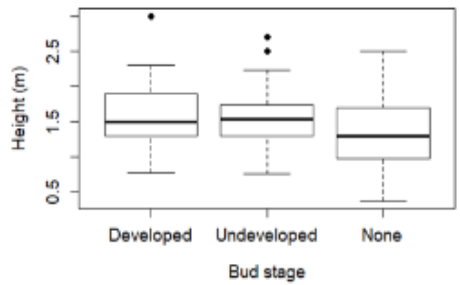

Figure 2. Boxplot of height (with averages) for blooming, budding, and non-budding B. pilularis.

Literature Cited

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