

Color polymorphism in *Boechera stricta* due to phenotypic plasticity and
reproductive advantage

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Abstract: Populations of *Boechea stricta*, a perennial plant species have both white and purple flowers.

We took soil samples to see whether this was due to phenotypic plasticity and we measured the number of siliques to determine whether one color morph had apparent reproductive advantage over the other. We found that the soil surrounding purple plants had a lower pH than the soil surrounding the white ones. It did not appear that one color morph produced more siliques than the other, suggesting that rare purple flowers are not at a reproductive disadvantage.

Keywords: *Boechea stricta*, phenotypic plasticity, soil pH, floral color polymorphism

Introduction

There are numerous ecological limits on growth and reproduction in plants as well as animals. Some of these are genetic and evolve over an ecological time scale, while others have to do with phenotypic plasticity. Phenotypic plasticity is the capacity of an organism to alter its physical morphology in response to different environmental factors (1). Plasticity has been documented in a number of traits, including plant height and color (physical morphology) and the timing of reproductive (1). Phenotypic trait differences in populations inhabiting heterogeneous landscapes can be due to phenotypic plasticity or fixed genetic differences (2).

Color polymorphisms within species occur relatively infrequently overall in the flower-baring community [3]. Flower color polymorphisms have been studied in other species [4,5], but little is known about the flower color variation in the *Boechea stricta*.

Boechea stricta, a perennial species of mustard found in the Rocky Mountains and other parts of North America[6,7], exhibits a flower color polymorphism. Although the majority of individuals produce white flowers, a small percentage of plants produce pink and/or vibrantly purple flowers. Although floral

color polymorphisms have been documented in other angiosperms as well, virtually nothing is known about this polymorphism in *B. stricta*. *B. stricta* grows in a variety of environmental conditions from meadows to forests (8). Variation in edaphic conditions, such as soil pH, could influence the development of flower color. In this case, the pH of the soil may be the deciding factor in the color of the flowers that the plant displays. They range from white to deep purple and some plants even exhibit both.

In addition to assessing the causes of this flower color polymorphism, it is important to understand their evolutionary consequences. For example, is the rare purple flower at a reproductive disadvantage? It is possible that pollinators may not visit this morph as frequently as they visit the dominant white flower. Additionally, other phenotypic traits may vary between the color morphs. Size and number of leaves, average height of the plant, size of blooms, and number of seeds produced. If the bloom of one color morph is bigger or one morph is taller, for instance, perhaps more pollinators will be attracted to that morph. One phenotype will most likely have reproductive advantage if it is pollinated more frequently.

In this study, I assessed the ecological causes and evolutionary consequences of variation in flower color. Specifically, I addressed whether soil pH influences flower color. I also quantified reproductive fitness (number of fruits) to determine whether white flowers have a reproductive advantage.

Methods

Soil samples were collected from a variety of blooming *Boechea stricta* plants at several different sites chosen at random. Three field sites were set up: one in a meadow by a spruce fir forest, one in a marshy area close to willows, and one in an open area by a roadside. The meadow site was located at an elevation of about 10,000 ft, off the Copper Creek hiking trail. The marshy one was located off the 401 biking trail at about 9900 ft, and the open site was off the side of Gothic Road at an elevation of 9600 ft. Each was selected for variety as well as abundance of *B. stricta* populations. The plots were 7m x 7m and at least 3m from any path or road. When an area was chosen, in order to ensure the

randomness of the sample spot taken, a flag would be thrown by a spinning person with closed eyes. This flag would mark the upper right corner of the plot.

There were 31 plants in the meadow site, 46 plants in the willow site, and 89 plants in the open plot. The soil in these sites was also tested and the plants were monitored for color change.

Samples were taken from purple flowering plants and white flowering plants. These samples were tested using a soil pH, as well as nitrogen, phosphorus, and potassium, testing kit (Markson Lab Sales, Soil Test Kit).

Several plants, both purple and white, were marked with flags and when the silques on the specimens reached maturity, the number of silques was quantified. In order to account for plant size, the amount of leaves was also counted on each plant. Some of these plants were in the monitored field sites while others were chosen randomly and marked. Twelve random plants were successfully tested in total, creating a small sample size.

To analyze the data, outliers were searched for in the set. When none occurred, the average of the soil pH surrounding each color morph was measured. Then, the proportion of silique number per plant in regards to leave amount was measured and averaged.

Results

The white color morph proved more prevalent throughout the area studied. While the field site by Copper Creek had 21 white and 10 purple plants, both the marshy and the open plots were overwhelmingly white.

Soil pH close to the white flowering *Boechera stricta* was slightly basic while the soil pH close to the purple flowering *B. stricta* was slightly acidic (Figure 1).

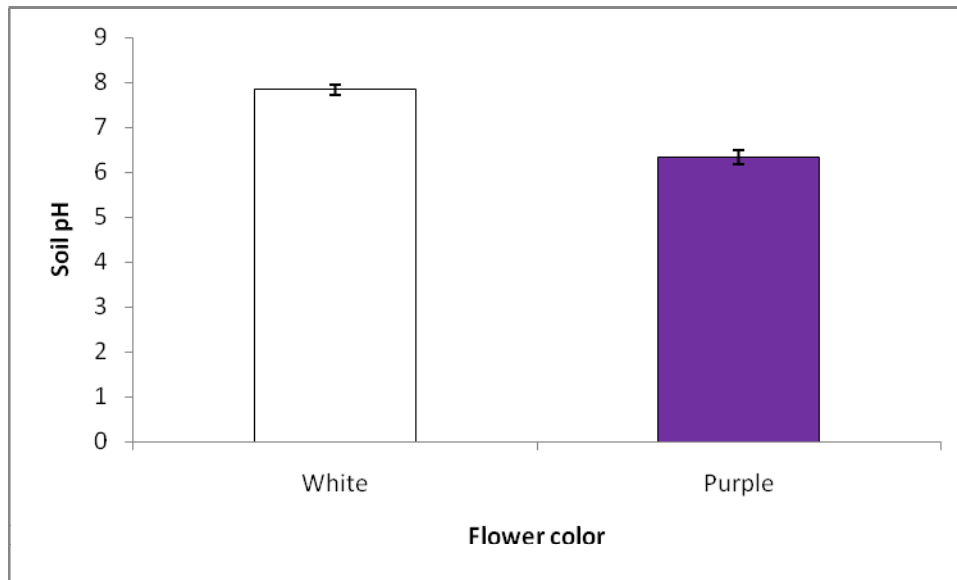


Figure 1: Mean pHes of the soil surrounding the roots of white flowering *B. stricta* and purple flowering *B. stricta*.

The number of siliques versus the number of leaves was not significantly different when observing white and purple plants. The number of leaves was close to the number of silques on both color polymorphisms in every observed specimen. The number of siliques was not high for one color morph or the other.

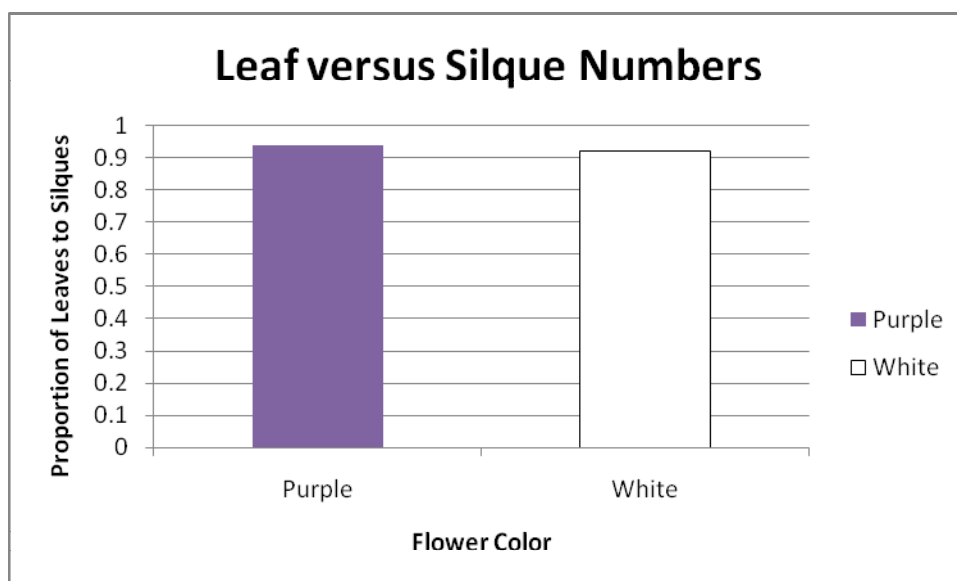


Figure 2: Mean proportion of each color morph's number of leaves compared to silques.

Color rarely changed in individual plants, but there were 2 out of 156 documented cases of white blooming plants suddenly blooming purple.

Discussion

The purpose of this experiment was to discover whether soil pH influenced the variation in color among the *B. stricta* populations of Gothic, Colorado and the surrounding area. There were a couple of color change throughout the summer months in plants from white to purple and in controlled populations, cloned genotypes displayed separate colors, so we believe this trait is phenotypically plastic. We found that the main difference between the color morphs was the pH of the surrounding soil. The white plants grew around more basic soil and the purple around more acidic soil.

The results are similar to what occurs in the hydrangea plant (9). Based on its environment, particularly the pH and aluminum amounts in the soil, the hydrangea plant's sepals will turn out a certain color (9). When the soil is more acidic, the amount of available aluminum in the soil increases and this factor turns the sepals on hydrangea plants blue. In more basic soil, the plant may have red, pink, or white sepals (9).

This result is not common in many species of angiosperms. To my knowledge, prior to this study, the only commonly known flowering plant that drastically changed color due to soil pH was the hydrangea. Follow ups on this study that observe pollinator preference and address other possible factors of reproductive advantage depending on color morphs would significantly add to the knowledge of this topic. Also, perhaps this project could be repeated with a larger sample size.

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