FLORAL COLOR CHANGE AND POLLINATION

In Aster

Observations – The white wood aster (Aster divaricatus) and crooked-stemmed aster (Aster prenanthoides) have small flowers that are aggregated into inflorescences, or heads. Each head consists of two flower types, disk flowers and ray flowers. The ray flowers are at the periphery of the head, and each bears a single, white, strap-like petal. These flowers are pistillate, containing functional stigma, style and ovary, but no male parts. Within the ring formed by the ray flowers are the disk flowers. These lack the strap-like petals of the ray flowers but each contains a stamen and a pistil. The disk flowers are protandrous, meaning the pollen is available before the stigma becomes receptive. The lengthening pistil pushes the pollen up the corolla tube. In a newly opened head, the corollas of the disk flowers are yellow, but in older flowers they become red or purplish.

Hypotheses – Floral color changes are common among the angiosperms, and during the past two decades, the functional significance of these changes has received increased attention. At least three non-exclusive hypotheses have been proposed in the scientific literature to explain these changes (Gori 1983):

- Once flowers are adequately pollinated, further pollinator visits impair reproduction by deposition of self-pollen, dislodging of pollen, or damage to floral parts.
- Color changes mark flowers that have been depleted of their rewards (nectar or pollen). This could be advantageous to the plant in that it would make the plant more rewarding to pollinators and hence more likely to be visited.
- Color changes mark sexually non-functional flowers, minimizing pollinator removal of inviable pollen or deposition of pollen on non-receptive stigmas.

A second question related to floral color change is why such changed flowers should be retained at all. Two possible non-exclusive hypotheses are:

- Retention permits recapture of some nutrients, and
- The presence of changed flowers enhances the plant as a visual target for pollinators.

Specifically, this proposed study would investigate the latter hypothesis that suggests the presence of color-changed flowers enhances the plant as a visual target for pollinators. We will examine floral color change in Aster divaricatus or A. prenanthoides to determine:

1. Whether the floral color change is correlated with other visible changes in floral parts, particularly the sexual parts, and
2. Evaluate the significance of the presence of older red heads for pollinator attraction.

Methods – To test (#2) the importance of the red heads in attracting pollinators, we will select and cut replicates of four flowering aster stems. We will select these stems so that the total number of open heads on each stem is similar, and try to select stems growing in proximity to one another. Two stems will be arbitrarily selected and all red heads will be clipped off with scissors. The number of yellow heads on all stems will be adjusted so that they are equal. A head will be counted only if its petals are held
horizontally rather than vertically. The number of red heads in the two remaining stems will be counted and recorded. The stems will be snipped so that they are all of equal height and will be placed individually in a water-filled test tube. We will place four stakes in the ground at the corners of a 0.5 m square and will attach the tubes to the stakes with rubber bands. Thus, the two stems in each treatment will be at opposite corners of the square, and all inflorescences will be held at a similar height. We will watch from a discreet distance (2 m) with observations of each floral array lasting one hour. We will record the number of visits to each stem, the number of heads visited, and the color of each head. We will also record the identity of each visitor (probably honeybee or bumblebee). Two or three replicates of this design will be repeated on at least two afternoons for a total of four to six replicates.

To determine (#1) whether any floral events accompany the color change, it will be necessary to examine several heads of each color under a dissecting microscope in the laboratory. Before examining each head under the microscope, we will assign it to either the red or yellow category as we did in the field portion of the experiment. Again, we will record the number of ray flowers open and closed and the number of disk flowers in each of the following phases:

1. Yellow corolla closed in bud
2. Yellow corolla open, flower in male function
3. Reddish corolla open, flower in female function
4. Corolla and/or stigmas browning, not receptive

We will record this information for a total of six heads of each color category and will note the spatial patterning of flower opening within the head.

Data Analysis – We will summarize the total number of visits to experimental (yellow only) and control (red and yellow) stems. Next we will perform a chi-square analysis to test the null hypothesis that pollinators do not discriminate among stems.

We will also calculate mean numbers of heads visited on control and experimental stems and will test the significance of the difference between treatments with a t-test.

For control stems, we will count the total number of yellow and red heads and will count the total number of heads visited on all control plants. Assuming that pollinators do not discriminate between yellow and red heads, we will calculate the expected numbers of visits to each head type and will compare actual and observed with a chi-square test.

Finally, we will summarize the floral phenology data into a figure that clearly illustrates the correspondence of color change with floral events. We may find it best to display a subset of the data to make a point more effectively, e.g., dealing specifically with male (stage 2) versus female (stage 3) phases, or presumably receptive phases (stages 2 & 3) versus presumably non-receptive phases (stage 4).

REFERENCES


