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Exploring the Open-Close Mechanism of Dimorphotheca aurantiaca: Day versus Night and Cold versus Hot Temperatures

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Abstract

In the spring of every year on Pepperdine University's campus, patches of hills are covered with the South African native flower *Dimorphotheca aurantiaca* or more commonly known as the African Daisy. An observation of the opening and closing mechanism of the flower triggered an important question: does the flower change its shape based on temperature or the presence of light? At night, the African Daisy closes and then opens up again in the daytime. Because temperature has such strong effects on different species of ectodermic animals and temperature-sensitive plants, we hypothesized that the change in temperature initiates the flower's morphological change. Six flower pots were placed in warmer temperature and then in colder temperature, both under light and then under darkness for six-hour periods. The infrared thermometer was used to accurately measure what temperature the flowers were detecting. Ultimately, we did not reject the null: The African Daisy responded more significantly to change in light exposure than to change in temperature. This discovery reveals that the flower detects light to maintain its survival.

Introduction

Dimorphotheca aurantiaca, or African Daisy, refers to any African native plant that has daisy-like flowers. It spreads annually and has now naturalized throughout the southwestern part of the United States. Flowers vary greatly from white, yellow, orange to purple, and it is an excellent performer to observe and study in early spring when it blooms the fullest. *Dimorphotheca* have been long observed to be tolerate high temperatures (Rother, 2001), which can be attributed to their survival in Southern California. Based on our preliminary observation, this species shows a strict mechanism of closing during the night and opening during the day. This simple yet interesting observation has allowed us to come to question the cause and reasoning behind this behavior. Realizing the importance of this behavior can help reveal the mechanisms of the African Daisy's means of survival in the rather dry environment in Southern California. From observation of the ambient conditions between day and night, we hypothesize that the flower petals react according to the change in temperature. The null hypothesis is that there would be no differences in the flower petals following changes in temperature. In order to go about testing the hypothesis, we will perform a series of experiments with two sample groups of African Daisies in two light/temperature-controlled chambers. Both chambers under light will have two different atmospheric temperatures (11˚C, 23˚C) and the effect of temperature on petals will be measured using infrared thermometer (temperature of the petal) and metric ruler (distance between the farthest petals). A second experiment will be performed the exact same way under no light. To test our hypothesis, data will be gathered to find the correlation between light reception and temperature effect on flower opening.

Materials & Methods

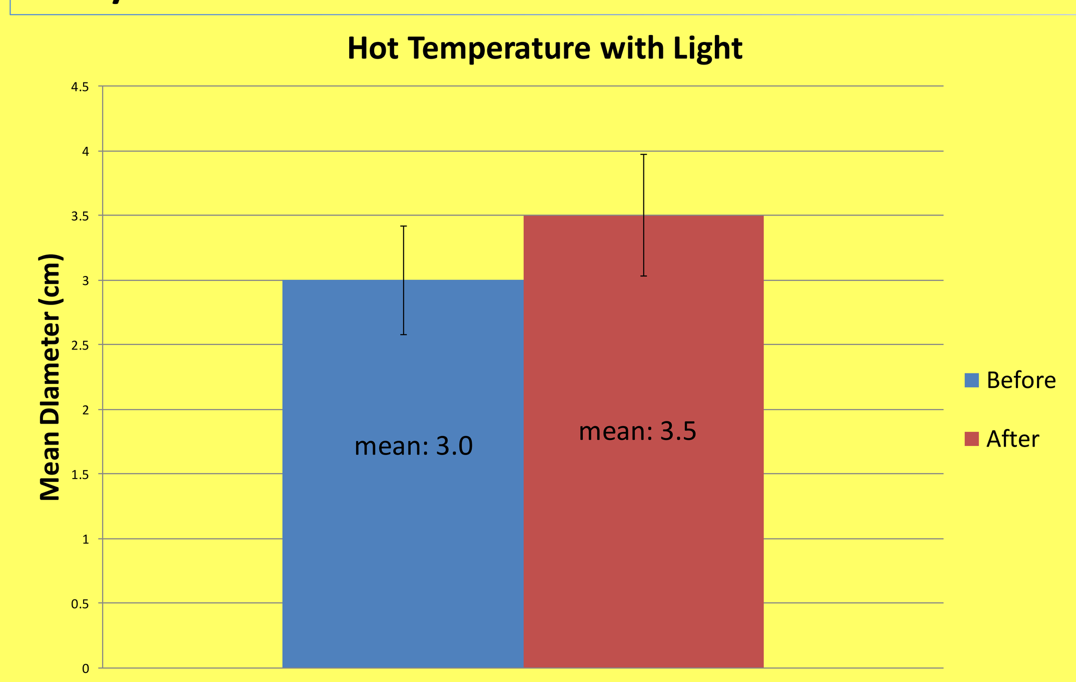
The materials we used were: 12 pots of African Daisies, metric ruler, Infrared thermometer, 2 temperature, light controlled chambers, 12 plastic bags

12 pots of African daisies were obtained from the Pacific View Nursery. They were divided and placed into two different chambers: 6 pots were labeled C1~C6 and the rest were labeled H1~H6. The two chambers were maintained under exact same conditions under bright light except for the temperature. Six pots labeled C1~C6 were placed in the first chamber kept at 11 °C. Another set of six pots labeled H1~H6 were placed in the second chamber kept at 22°C. Data was gathered after 6 hours, and water was given every other day to prevent dehydration. Data consisted of distance between petals that were extended out the farthest and temperature of each flower. After observation and data collection, all the pots were taken out of the two chambers and were placed in the room temperature. Each pot was watered and was covered with plastic bag in order avoid drying out. After a week, the pots were again placed into the same two chambers but with no light. Data was collected the same way for this segment of data collection as was done for light environment.

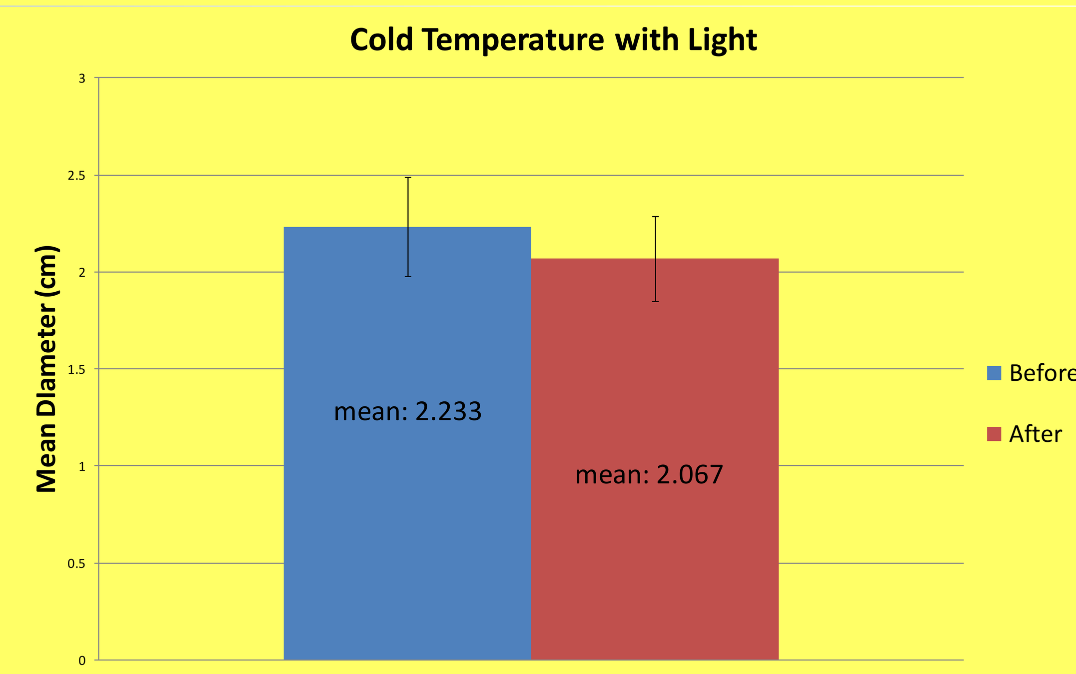
Acknowledgements

First off, we would like to thank Dr. Stephen Davis for introducing us to the wonderful world of botany and giving us access to all of the materials that were needed for this experiment to be possible. We also thank Pacific View Nursery for providing the 12 pots of African Daisies, and last but not least, Dr. Daphne Green, for helping us and supporting our experiment financially and giving us access to the student labs.

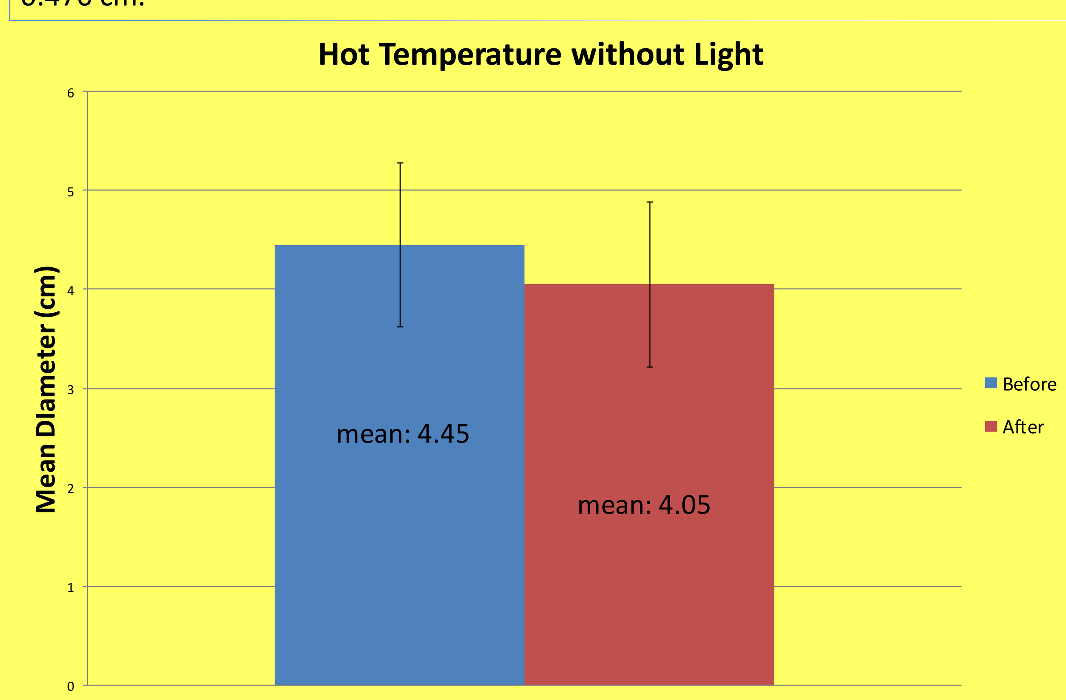
Data/ Results



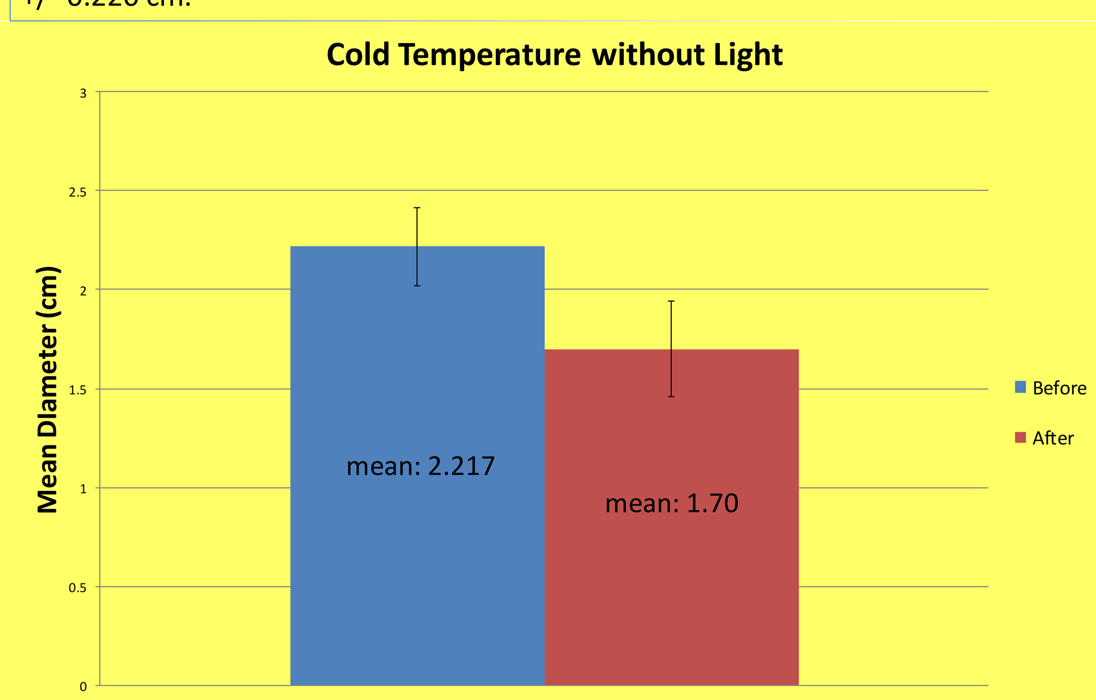
Graph #1: Mean diameter of *Dimorphotheca aurantiaca* initially placed in a warmer temperature environment with light. The average temperature recorded was 25.73°C. Note that the diameter changed significantly (p=0.0016) and opened up more. SEM of before in blue: +/- 0.419 cm. SEM of after in red: +/- 0.470 cm.



Graph #2: Mean diameter of *Dimorphotheca aurantiaca* initially placed in a colder temperature environment with light. The average temperature recorded was 11.77°C. Note that they closed up more, but the diameter did not change significantly (p=0.0925). SEM of before in blue: +/- 0.256 cm. SEM of after in red: +/- 0.220 cm.



Graph #3: Mean diameter of *Dimorphotheca aurantiaca* initially placed in a warmer temperature environment in the dark. The average temperature recorded was 23.43°C. Note that the diameter changed significantly (p=0.0388) and closed up more. SEM of before in blue: +/- 0.831 cm. SEM of after in red: +/- 0.831 cm.



Graph #4: Mean diameter of *Dimorphotheca aurantiaca* initially placed in a colder temperature environment without light. The average temperature recorded was 12.55°C. Note that the diameter changed significantly (p=0.0013) and closed up more. SEM of before in blue: +/- 0.199 cm. SEM of after in red: +/- 0.242 cm.

A paired t-test was performed on each treatment, comparing "before" (or initial) and "after" diameters in different environments. Graph #1 reflects the six flowers that were maintained in an environment with normal light. According to the statistical analysis, the flowers opened up significantly, with a p-value of 0.0016 and low variability (variability is noted on each graph). The standard error of difference was 0.089. Under colder temperatures with light (Graph #2),the flowers closed up, but not significantly, with a p-value of 0.0925 (greater than 0.05). The standard error of difference was 0.080. In graph #3, results from hotter temperatures without light are shown. The flowers closed up significantly (p=0.0388) with standard error of difference of 0.144. Finally, graph #4 shows the changes the flowers underwent in cold temperatures in the dark. The flowers closed up significantly (p=0.0013) with standard error of difference of 0.079.

Discussion

An infrared thermometer was used to obtain the average temperature of the flowers in order to reflect maximum accuracy. A chamber at 24°C, for example, will not necessarily reflect the temperature of each flower. Also, the temperatures from after six hours were the ones taken and used because it gave a more accurate temperature that the flowers had acclimated to. In the end, the temperatures in light and dark were comparable and were not extremely off (25.73°C versus 23.43°C and 11.77°C versus 12.55°C).

The most significant change was observed in flowers under warm temperatures with light, where the flowers opened up. The other considerably significant change was seen in flowers under cold temperatures without light, where the flowers closed up. Finally, in warm temperature with no light, the flowers did significantly close, but with a big p-value (almost to 0.05). When flowers were placed in cold temperatures in light, the flowers closed but it was not statistically significant.

Every flower responded roughly the same way in each particular experiment. They all either opened or closed, but some opened more than others. Based on the results, *Dimorphotheca aurantiaca* opens during the day and closes at night because of light reception. During the day, the temperatures are much hotter, but that did not affect the flower significantly in the dark; therefore, the flowers remained closed since they were in the dark environment.

In the article from the journal *Plant Disease*, another possible explanation can be given about the open-close mechanism of the African Daisy (Aiello et al., 2008). They may close as a means of survival. In this report, they observed how damping-off affected the plant. Damping-off occurs when fungus thrive in high humidity and attack seedlings at the base. Excessive moisture typically occurs during the day in the light, when the flowers are open. This morphological feature may protect the base from any attack. Although this disease occurs in the seedlings, wilt symptoms and lesions at the base of stem identical to those observed developed seven days after inoculation of the fungus in the experiment, and all inoculated plants died within 20 days. If an African Daisy plant were to survive, it would have to have some protective mechanism to block off any future attack during the day when humidity is typically higher. Another thought to explain the African Daisy's mechanism involves its sugar production and oxygen emission. Since this experiment established that the flowers open and respond mostly to light, it may be simply to maximize photosynthesis since the petals are modified leaves that can perform photosynthesis, however much it will be.

Conclusion

- The African Daisy reacts more significantly to light reception than to temperature.
- Light reception does cause opening and closing of the petals, but because it had an almost insignificant p-value (p=0.0388), it could be that further factors contribute to the open-close mechanism.
- Future research can involve the relationship between insect pollination and opening of the petals.
- Significance was found which could help reveal the mechanisms of the African Daisy's means of survival in the dry environment of Southern California.
- Improvements can be made in the future by performing a more continuous study (plants remain in one chamber for 12 hours in one temperature in light, then lights shut off at 6-hour mark). This will minimize fluctuation.
- Also, for more accurate results, the experiment can be performed for a longer period of time (over the course of months) and also with a greater number of specimen.

Literature cited

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