The Effects of Temperature and Light Intensity on Pollination Frequency of *Prunus serotina* at Waldron Fen

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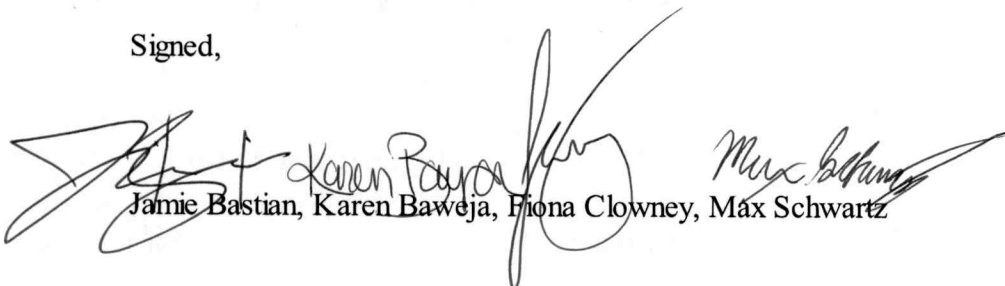
General Ecology (EEB 381)

June 12, 2013

Dr. Joel Heinen

Abstract

Black cherry (*Prunus serotina)* is pollinated by many different species of insects. The objective of this experiment was to understand what factors influence the frequency of pollination of flowers on *Prunus serotina*. We selected three individuals of *Prunus serotina* located within Waldron Fen in Emmet County, Michigan, and observed each twice throughout the day. The experiment looked into pollination as a function of sunlight and temperature at the time of observation. In our final analysis, there was some indication of a correlation between the amount of sunlight flowers receive and the number of pollinators. There was, however, no correlation found between temperature and the number of pollinators a flower receives.

Signed,

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Introduction

      Prunus serotina, informally known as the black cherry, is a deciduous tree in the Rosaceae family common to the eastern half of North America (Uchytil, 1991). The Black Cherry tree is widely distributed in the northern region of the Lower Peninsula of Michigan. *Prunus serotina* is shade tolerant when young, but becomes shade intolerant at maturity (Barnes and Wagner 2004). The tree is morphologically distinct in forests versus open areas. In forests, the trunk is relatively straight and reaches the canopy, whereas in open areas the trunk is shorter and branched, with a spreading, irregular crown (Uchytil, 1991).

      This dioecious tree has perfect flowers borne on three to six inch racemes (Uchytil, 1991; Barnes and Wagner, 2004). The flowers appear from late April to early June when the tree has foliage (Barnes and Wagner, 2004). Pollinators of *Prunus serotina* include bees and flies (Hilty 2012). We investigated differential visitation rates by pollinators to black cherry trees based on temperature, aspect with respect to the sun and overall light intensity. Flowers on the trees receive varying amounts of sunlight at different times of day based on their directionality. Flowers facing south receive greater and more direct sunlight than those facing north. Flowers on the east receive greater and more direct sunlight in the morning than those facing west, and those on the west receive greater and more direct sunlight in the afternoon than those facing east.

      Since bees prefer to forage at higher temperatures (Mayer et al. 1986), it would follow that we would see an increase in bee pollination when it is warmer. Honeybees are especially active between 15 °C and 40 °C (Anon 2013). At temperatures below 12°C, bee foraging falls below 21% (Mayer et al. 1986). Our first hypothesis is that insects will pollinate more cherry flowers at higher air temperatures. Our second hypothesis is that there will be an increase in pollination of flowers that receive more sunlight

than those that are shaded. Therefore, there should be an increase in pollination of flowers that are on the south sides of trees versus the north sides. Additionally, we expect an increase in pollinators on the eastern sides of trees during morning observations. Likewise, we expect an increase in pollinators on the western sides of trees during afternoon observations. Our third hypothesis is that there will be an increase in pollination events on the plots that are higher up versus the plots that are closer to the ground. We think this will be so because the plots that are higher up will receive more sunlight. Finally, our fourth hypothesis is that a greater light intensity will lead to an increase in overall pollination rates.

Methods

The study was conducted at Waldron Fen over a three week time period. During an initial visit, cherry trees surrounding the fen were examined and prospective trees were selected based on several desirable traits and marked using marking tape. Chosen trees were located on the northern edge of the fen and were similarly isolated from the shade and growth of other trees and plants in order to control for the effects that surrounding vegetation may have on pollination rates. In addition, the trees that were chosen appeared to have a significant amount of living buds growing on all sides at similar, reachable heights. A total of thirteen trees were marked, and the buds of the trees had the appearance of successfully flowering within twelve days of marking the trees. Coordinates of latitude and longitude were recorded for each tree using a GPS. The coordinates were used with Google Earth to create a visual map of the study site (Fig. 1).

Once the buds of the cherry trees began to flower, the three trees that best fit the requirements listed above were chosen as subjects for the remainder of the study. Observational studies were conducted on the trees during two time periods throughout the day: in the morning, between 9:00 and

11:00 am; and in the afternoon, between 1:00 and 3:00 pm. Beginning in the morning, a compass was used to find the north, south, east, and west sides of the trees and measuring tape was used to measure up to heights of 1.5 m and 2 m on each of the four sides of the tree. Starting with the lower height of 1.5 m, four plots containing a similar number of blossoms were chosen and measured using 25 cm × 25 cm PVC pipe frame.

Weather conditions were observed before sampling. Wind direction was recorded and assigned a rating of strength: absent, mild, or strong. The amount of sunshine was rated as sunny, partly cloudy, and overcast and the temperature as hot, mild, and cool. Immediately before and after sampling, the air temperatures were recorded near the tree and averaged. Before each sampling session, a photometer was used to measure lux, a unit of light intensity, at each side of the tree. The plots were observed by all four researchers during 10 minute intervals, with one observer at each side of the tree. The number of times a pollinator visited a flower within each plot was recorded with hand counters. A stopwatch was used to measure the 10 minute period. After a 5 minute break, the same methods were used to collect data on the number of pollinators for the four higher plots on the tree. When pollinators were sparse, both the upper and lower plots were observed during the same 10 minute period. In total, pollination rates were observed for eight separate plots on the tree within 30 minutes of each other. The process was repeated for the remaining three trees during the morning time period, and the entire process repeated in the afternoon for all selected trees. The trees were sampled on three separate days over the course of one week.

To find the relationship between number of pollinators and temperature, a linear regression test was run. To determine the relationship between number of pollination visits and the side of the tree

during morning and afternoon, independent samples T-tests were run for the east and west sides of the trees. To determine whether or not there were more pollinators on the south side than on the north side of trees, an independent samples T-test was run. To determine the relationship between overall light intensity and the number of pollinators, a linear regression test was run.

Results

A regression analysis was run to determine the relationship between temperature and the number of visits by pollinators. A slight correlation was observed, but the results were not significant at the $\alpha=0.05$ level.

To determine whether or not south sides of trees received more pollination visits, an independent samples T-test was run. A strong correlation was seen (p=0.032). The mean number of pollination visits per viewing time for the north side of trees was 0.29. The mean number of pollination visits per viewing period for the south sides of trees was 0.50.

To test whether or not the east side of the tree would receive more pollination visits during the morning than the afternoon, an independent-samples T-test was run. The grouping variables were the east side of every tree during the morning and afternoon viewing times. The results showed a significant correlation (p<0.001). The mean number of pollinators per viewing time on the east side was 1.58 in the morning viewing times and 0.19 in the afternoon viewing times.

Likewise for the west side of the tree, an independent samples T-test was run comparing the west side of the tree in the morning and the afternoon with the number of pollination visits. Like the first T-test, the grouping variables were the west side of the tree during the morning and afternoon viewing times. The results suggested a significant correlation (p=0.004). The mean number of pollinators per

viewing time on the west side was 0.25 in the morning and 2.25 in the afternoon.

To test the relationship between plot height and number of pollination events, a one-way ANOVA test was run. The average number of pollinators was 1.04 on the lower plots and 0.45 on the higher plots. Although the results were not significant at the $\alpha=0.05$ level, a correlation was seen that does not support our hypothesis.

To determine the relationship between light intensity and number of visits by pollinators, a regression analysis was run. Although a slight correlation was observed, the results were not significant.

Discussion

One explanation for why no correlation was found between temperature and number of pollination visits was the lack of variation in the temperature recorded each day. Throughout the study temperatures were around 23 °C. The lowest temperature recorded was 18.5 °C and the highest was 28.5 °C.

The trees chosen skewed the test for our second hypothesis that a greater intensity of sunlight would correlate with an increase in pollination visits. Although all three trees were similarly isolated, each tree had adjacent vegetation on the south sides (Fig. 1). The effects of the adjacent vegetation caused the south side to have a lower intensity of brightness across all plots. The south side of the tree had an average of 28,404 lux versus the north side, which had an average of 39,582 lux. The first part of our hypothesis that the south side of the tree would receive more pollination visits was supported by the data. We hypothesized this because we thought the south side would have greater light intensity. Since the south side actually received less light than the north, we predict that the south side received more pollinators because it came in closer contact with other plants in the fen that contributed to the

attraction of pollinators. The north side was located along an open field, receiving more light but fewer visits from pollinators, possibly because it was farther away from other plants (Fig. 1). The second part of this hypothesis was supported by our data showing that the eastern plots received an increased number of pollination events during morning observations and western plots received an increased number of pollination events during afternoon observations.

Our third hypothesis that plots higher in the tree would receive more pollination visits than low plots was not supported by the data. A possible explanation for this is that lower plots may be easier to find for certain insects. According to optimal foraging theory, insects would minimize the amount of work they do for the energy gained.

Our fourth hypothesis that a correlation between light intensity and pollination visits would be seen was not found to be significant. A possible reason for this was that the photometer used on the first day of sampling was not working properly. When the photometer was working, light readings were never consistent. By the end of the day, we were unable to get any light intensity readings at all on our trees. If we were able to get consistent readings across all times and days, perhaps a significant correlation would have been found. The second photometer we acquired following the first day of observation was functional. However it too was never consistent, with readings fluctuating from 0 lux to about 81,000 lux in a matter of seconds.

Different plant species within communities have coevolved to flower at different times of the year. It has been suggested that this is an isolation barrier to avoid cross-pollination with other species (Li et al. 2011). The differences in phenology among species allows pollinators to visit only the flowers of one species within a given foraging trip. However, there is often a slight overlap in the flowering times

of different species. During this time of overlap, pollinators may initially visit multiple species of plants in a single foraging expedition but quickly develop a search image for a specific species (Heinrich 1975). This is useful for all of the flowers involved as they each experience less cross-pollination and more accurate pollination. Since we were unable to observe the cherry trees directly after flowering time, it is likely that our observations were occurring during a time of overlap with other flowering species. The presence of another blossoming flower could be a reason for the lack of pollinators seen at the *Prunus serotina* trees. For instance, two of the sampled cherry trees and most of those marked for possible sampling had an adjacent flowering plant. During our observation periods of *Prunus serotina* we noted that these unidentified saplings received a significant amount of pollination visits from bumblebees. Therefore there is a possibility that the plant species and *Prunus serotina* were competing for pollinators. Although we were able to observe a few instances of pollination of *Prunus serotina*, many of the pollinators had probably already switched their search image to a more rewarding flower which is why there were significantly less pollination events on *Prunus serotina* than expected.

The amount of food reward that a flowering species yields and the amount of other pollinators already foraging on the species are factors related to the eventual flower choice by the pollinator (Heinrich 1975). The choice of flower also depends on distance from a pollinator's nesting site. If there was a grove of *Prunus serotina* or another flowering plant closer to the pollinators' nesting site, the extra fly time to Waldron Fen would be unnecessary. Additionally, when non-native species are introduced they may bring in competition for pollinators to a community by flowering synchronously with native plants (Dante, 2013). An introduced species will blossom based on phenology which did not coevolve with the surrounding flowers. This introduced species may be viewed as more rewarding to

pollinators. If such a species was blossoming in Waldron Fen or the surrounding area it would lead to a decrease in visitation rates of pollinators to *Prunus serotina*.

By the time sampling began on the *Prunus serotina*, their flowers were beginning to die. The petals, usually white, were browning and dropping easily with slight wind (Fig 2). The death of the flowers may have occurred because as the *Prunus serotina* blossomed, late spring frosts occurred, which may have caused the flowers to die. Due to the timing of our observations, we were unable to sample the trees after they had blossomed but before the frost occurred.

The primary pollinator visiting *Prunus serotina* during our observation periods were flies (Fig. 3). Windy and cloudy conditions on all three of the observation days may have stirred a greater number of honey and bumblebees away from the *Prunus serotina*. The first day of observation revealed that most of our pollinators were mosquitoes. Following the frost, which occurred between the first and second days of observation, the number of mosquitoes pollinating sharply declined, and we also observed a sharp decline in mosquitoes in the surrounding fen area. The second and third days showed a higher number of flies and ants visiting the flowers, while the number of visits from bees remained fairly low. A suggested future study would be to compare the pollinator type over different weather conditions.

In this study there may have been a significant amount of human error in counting pollinators on our plots. Considering that many of the pollinators observed were relatively small, insects may have been less noticeable in the higher plots. Our presence, at 0.5 m away from the plots, may have discouraged pollinators from visiting the flowers. Also, the entire research team put on insect repellant before entering the fen, which may have deterred some pollinators. Lastly, our presence could have

encouraged mosquitoes to fester as mosquitoes feed on both mammalian blood and floral nectar

(Foster, 1995).

In the future, the research may be more successful if the *Prunus serotina* could be observed more frequently, that way the flowers could be viewed directly after blooming when pollination rates would be the highest. In addition, using a recently calibrated photometer, as opposed to our dysfunctional photometer, would allow for more accurate light intensity readings during observation periods. To find more distinct differences in pollination rates as a function of height, sampling plots could be taken at each half meter up the tree. This way, the top of the tree could be compared to the sides and the bottom to find the height preference of pollinators. Optimally, a research team would use a ladder to get within close proximity of the higher plots to obtain more accurate samplings. A more successful experiment would be conducted over a longer period of time, and would measure plots at a greater height range to determine the true pollination patterns across the entirety of the *Prunus serotina*.

This study found that pollinators prefer the east side of the tree in the morning, and the west side of the tree in the afternoon. We speculate that perhaps the pollinators do not respond only to light intensity but also proximity to other plants. We found that within 1.5 to 2 meters from the ground, pollinators prefer to visit flowers in lower plots. A major issue to deal with in such a study was the phenology of *Prunus serotina*. The flowering period seemed to be quite short and needed to be closely monitored so as not to miss crucial pollination dates. Overall, our study shows that weather patterns not only affect plant growth through a season but pollinator visitation rates during flowering time.

Figures

Figure 1. Bird's eye view of the north section of Waldron Fen, with the three trees studied marked.
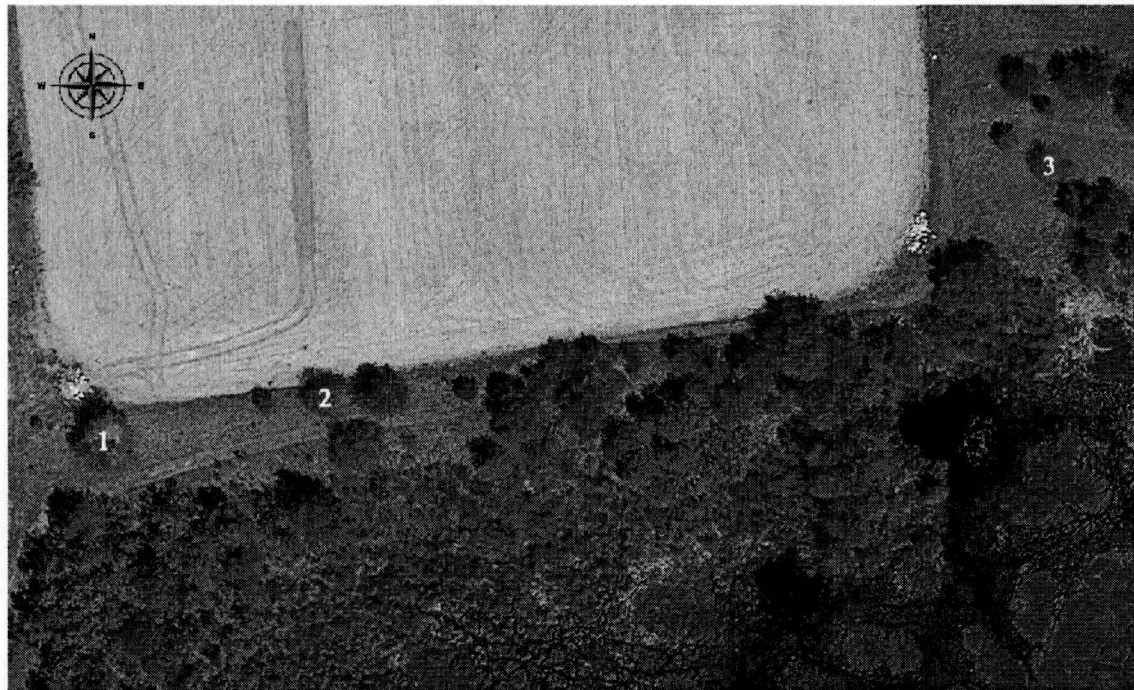

Figure 2. A shows a flower in peak blossom time on the first fen visit. B shows an inflorescence that has lost petals on the second fen visit.

Figure 3. Frequency of pollinator visits over all three days, on all plots.

Insect	Fly	Mosquito	Ant	Cuckoo Wasp	Bee
Day 1	1	20	1	0	2
Day 2	21	0	2	0	1
Day 3	14	0	0	14	3
Total	36	20	3	14	6

Acknowledgements

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