A Study on the Pollination of the Sarsaparilla Flower

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Abstract:

In this study, we examined the pollination rate of *Aralia nudicaulis,* commonly known as the sarsaparilla flower. Sarsaparilla is an angiosperm without specialized pollinators. We observed the plants at three different times of the day: early morning, afternoon, and early evening. We selected sites under heavy forest canopy cover, and also under moderate canopy cover. We used hand counters to count the number of pollination events within 15 minute time frames, and recorded the stalk height of the reproductive shoot, the number of umbels, and the percent canopy cover. Our tests showed that there was no significant relationship between the average stalk height and the total pollination rate, nor between the number of umbels and the total pollination rate. There was a significant difference between the average pollination rates between the moderately covered site and the densely covered sight, supporting our hypothesis that pollination rates are higher in more open areas. We found that pollination rates in the morning were significantly lower than pollination rates in the afternoon and evening. However, afternoon pollination rates were not significantly different from evening rates, refuting our hypothesis.

Introduction

Pollination is the process by which many angiosperms reproduce. Pollination is the exchange of pollen or genetic material via wind or via pollinators. By attracting pollinators such as insects, birds, and bats, plants are able to efficiently spread their pollen to other plants of their species. Flowers produce nectar, which is a food source for pollinators and the petals of flowers have evolved to be visual cues that attract pollinators to the flower. Many flowering plants have evolved tubular structures that hold the nectar and allow them to target pollinators with appropriately sized mouths (Ollerton and Coulthard, 2009). Some flowering plants produce nectar and petals that have co-evolved specifically with one or several pollinators, which allows them to attract specialized pollinators (Ollerton and Coulthard, 2009). However, not all angiosperms have specialized pollinators.

Previous studies have shown that pollination events tend to vary with changes in temperature and light exposure. Bees of different types have a certain window of conditions that allow them to forage. Thermal limitations on pollinators can lower flight activity and pollination rate (Corbet et al., 1993). Ghazoul (2002) showed that decreasing amounts of canopy cover in Thailand due to logging has increased the amounts of the invasive shrub *Chromolaena odorata* covering the ground. In disturbed forests with less canopy coverage, these invasive plants were visited preferentially by pollinators. This study demonstrates that deforestation not only increases the success of these plants due to an increased level of light for photosynthesis, but also it allows them to more successfully outcompete native plants for pollinators (Ghazoul, 2002).

Aralia nudicaulis, commonly known as the wild sarsaparilla plant, is an herbaceous plant with a widespread distribution ranging from northern Canada to the southern United States. *Aralia nudicaulis* has both a vegetative shoot and a separate reproductive shoot. The vegetative shoot consists of three whorls of pinnately compound leaves, with three to five leaflets and can be 30-40 cm tall (Naegle, 1996). The reproductive shoots usually consist of three umbels (Edwards, 1984). Although *A. nudicaulis* is dioecious, much of its reproduction is vegetative via underground rhizomes (Edwards, 1984). Despite this clonal growth, genets (clones), in close proximity are usually not related to one another (Edwards, 1984).

In this study, we observed pollination rates of the sarsaparilla flower at two different sites: one highly shaded by the forest canopy, and the other with moderate canopy cover. We first hypothesize that lower canopy cover will result in a higher rate of pollination. Our second hypothesis is that the pollination rates during the afternoon will be highest for all plots, due to an increase in temperature, allowing pollinators to be more active. Our third hypothesis is that the plants with taller reproductive shoots and a greater number of umbels will have a higher pollination rate.

Methods & Materials

Experimental Design

We conducted our study at the University of Michigan Biological Station near Douglas Lake in the northern lower peninsula of Michigan. We selected plants in an area along the main drive that was highly shaded by trees, and plants found behind the LaRue lab building that were moderately shaded. Over three days of data collection, we used a hand counter to quantify the number of pollinators that visited each flower during 15 minute sampling bouts at three different times of day: morning, afternoon, and early evening. We also recorded of the number of inflorescences in each plot, the temperature, and the time of day, along with descriptions of the weather conditions at each time.

Plot Selection

To test whether canopy cover affects pollination rates, five plots were made within areas of moderate canopy cover and five were made under high canopy cover. There were at least three flowering stems in each plot which ensured a sufficient sample size of flowers. Creating the plots was also necessary to make sure that the same group of plants would be observed in the subsequent days of our study. We chose to use the plots instead of marking individual plants, because we did not want any markings to affect the pollination rates.

Canopy Density Measurement

We used a spherical densiometer to measure the canopy density of our plots. Four measurements were taken at the center of each plot, facing each of the four cardinal directions. We added the measurements from each direction together and calculated average percent canopy cover for each plot.

Statistical Analysis

We used an independent samples t-test to compare total pollination rates between the high coverage plots and the moderate coverage plots. A linear regression was used to examine the relationship between pollination rate and number of umbels, and also to look for a correlation between pollination rate and height of flowering stalk. We used an ANOVA test to compare the pollination rates between the three recordings at different times of day.

Results & Discussion

To test our first hypothesis, we ran an independent samples t-test to analyze the total pollination rate between the high coverage and moderate coverage sites. The results were significant ($p = .024$), supporting our hypothesis that the pollination rates would be higher in the moderately covered site in comparison with the densely covered site. The average percent cover for the moderately covered site was 56.12% (Table 1), while the average percent cover for the densely covered site was 98.16% (Table 2).

We ran a linear regression to test for a correlation between the average number of umbels and total pollination rate. This test was not significant (R^2=.021, F=0.600, p=.445) as shown in Figure 1. We ran a second linear regression to compare average stalk height with the total pollination rate; this test was also not significant (R^2=.065, F=1.946, p= .174).

There was not a relationship between the average stalk height and total pollination rate (Figures 1 and 2). There was also no relationship between the average number of umbels and total pollination rate. Therefore, both sets of data do not support our hypotheses. The number of umbels and stalk height do not appear to have an effect on an organisms ability to find the flowers and pollinate. In the future, a possible way to improve this study would be to observe individual plants rather than patches so as to have more precise data. Hypothetically, the total number of pollinations in a plot could have remained relatively similar from plot to plot, even if some flowers in some of the plots were actually attracting pollinators much more efficiently than their neighbors. If taller stalks or stalks with more umbels were more successful, this might not have made the total pollinations per plot increase. Instead it could have increased the pollination rate of tall plants and plants with many umbels and decreased the pollination rate of the nearby flowers in the plot. Increasing our sample size so we could observe more plants with many umbels or more plants with varied stalk heights might be useful in future experiments.

An ANOVA test was run to test our hypothesis that the afternoon pollination rates would be the highest. The mean pollination rates of the different time frames were compared and there appeared to be a significant difference (p= .001). A Tukey's test was performed to determine where the differences occurred, which showed that the mean morning pollination rate was significantly lower, but there was no significant difference between the afternoon and the evening mean rates. This does not support our hypothesis that the afternoon rates would be the highest. It should be noted that the morning observations were conducted in rainy weather, which may have decreased the pollination rate.

The pollinators we observed during our data collection were all generalized pollinators. Bees, mosquitoes, flies, ants, and slugs all were found on the flowers. Ants were the most frequent pollinator that we found, although we did not keep separate counts of each type of pollinator, ants constituted a large majority of the pollinators. Future research could characterize the species pollinating sarsaparilla flowers by capturing and identifying pollinators. It may be interesting to study whether canopy coverage, temperature, and time of day among other factors affect the type of pollinator that most frequently visits. Past research has indicated that ant pollination tends to frequently occur in hot dry habitats with high densities of small plants at uniform heights, with low pollen volume and low nectar quality (Wyatt, 1981). Chemical analysis of the nectar and pollen of sarsaparilla could help to determine how much it has in common with plants pollinated exclusively by ants.

When considering the low correlation between stalk height and pollination rate, it may be relevant to consider that many of the observed pollinators were ants. This could suggest that increased stalk height may not contribute to increased pollination success, as ants approach flowers by climbing up their stalks. A higher stalk might be more attractive to flying pollinators, but higher stalks would only make pollination more costly to ants. It is possible that a stabilizing selection prevents flowering stalks from evolving to be too tall for ant pollination, and also prevents them from becoming too short to be noticed by flying insects. A way to test this hypothesis in the future would be to research whether flying pollinators land preferentially on the taller stalks, and if ants preferentially pollinate the shorter stalks.

The weather conditions that we observed during all three of our data collections are another variable that may have had an effect on the pollination rates we observed. We measured temperatures for each pollination rate we recorded, along with descriptions of the weather conditions. Weather events like light rainfall that occurred during some of our pollination observation periods could have had an effect on the level of pollinator activity. However, since we took the pollination rate of both of the sites directly after each other without a large time gap, the weather was relatively similar for both plots on a given time of day. Therefore the weather most likely had only a small confounding effect on our comparison of pollination rates between the covered and partially covered sites. The weather should have had no confounding effect on our hypothesis about stalk height and number of umbels and pollination rate, since the same plants were measured in all of the weather conditions. The main confounding effect the weather may have had was in our comparisons of pollination rates at different times of day. Since the weather changed during the day, and on one of the days there were rainy conditions only in the morning, the lower pollination rates in the mornings could have been partially due to weather. Future experiments could take more data in different weather conditions, and possibly quantify rainfall in order to determine how much the pollination rate is affected by the presence of rain.

The third and final day of data collection showed very low pollination rates. We observed that many of the flowers appeared wilted and their petals were falling. We assumed this to correlate with level of nectar inside the flowers and assumed it to be much lower, due to the flowers finishing their cycle. Different levels of nectar in flowers on different sampling days could have caused different pollination rates on different days. In a future experiment, we could attempt to analyze the amount of nectar in the flowers in a lab on the different days we take pollination rates. By doing this, we would be able to determine if pollination rates are correlated with the level of nectar in flowers, and how the level of nectar changes during the flowering period of sarsaparilla.

Our research indicates that pollination rates of sarsaparilla are higher in areas with less canopy coverage. However, there was no significant relationship between the number of umbels and the pollination rate and the relationship between stalk height and pollination rate was nearly significant at $\alpha=.05$ level but ultimately was not. Further research investigating pollination rates of individual flowering stalks would allow us to determine more precisely if the stalk height and number of umbels have any effect on sarsaparillas rate of pollination. Future research could also look into the particular species of pollinators and their pollination rates, along with the nectar levels in the flowers over time and its relationship to pollination rate.

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Table 1: Densiometry readings of moderately shaded area

Plot	% Cover
1	59.7
2	57.9
3	67.3
4	48
5	47.7
Average	56.1

Table 2: Densiometry readings of densely shaded area

Plot	% Cover
1	100
2	99.5
3	95.6
4	99.6
5	96.1
Average	98.2

Figure 1: Linear regression results showing correlation between the average number of umbels and total pollination rat

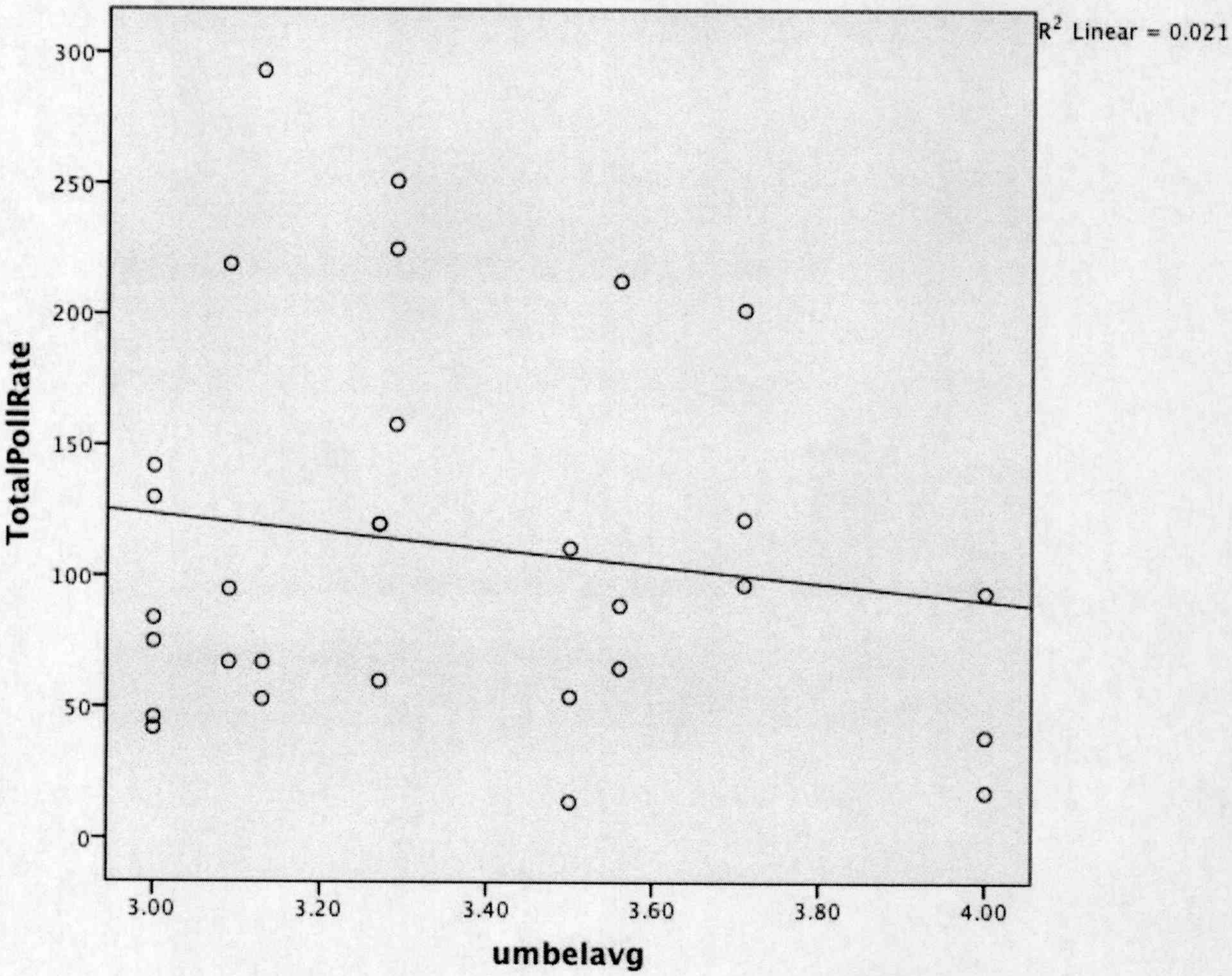
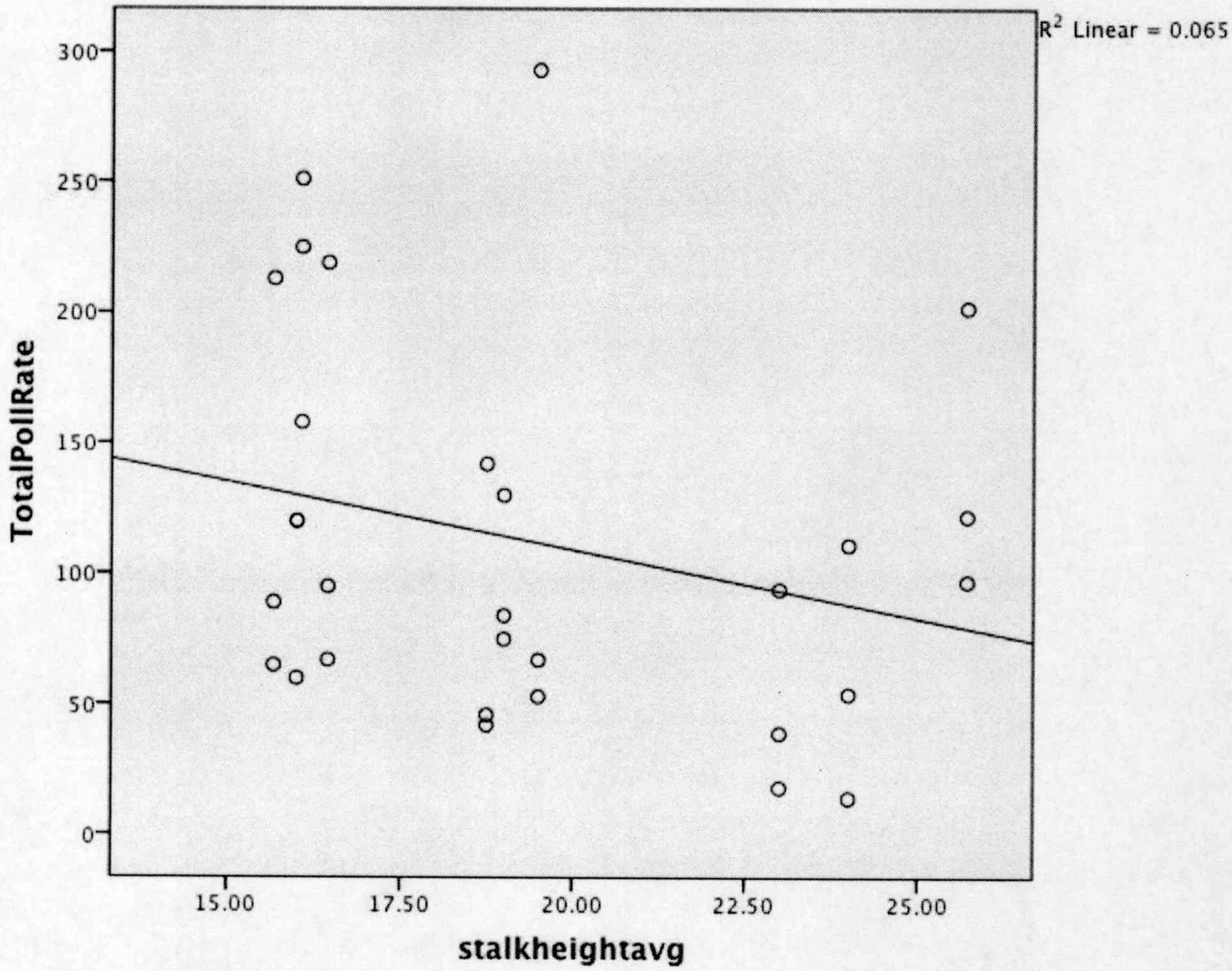


Figure 2: Linear regression showing correlation between average stalk height and total pollination rate



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