

How does road dust influence *Ipomopsis* pollination?

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Abstract

Premise of research. Road dust affects the quantity of pollen received by *Ipomopsis aggregata* flowers, with dusty flowers receiving less pollen than undusty flowers. One possibility is that hummingbird pollinators visit dusty flowers less and deliver less pollen. This could happen if dusty flowers produce less nectar.

Methodology. I collected a total of ninety-one *I. aggregata* flowers from experimentally dusted and non-dusted plants in Maxfield Meadow. The flowers had been enclosed in drinking straws for twenty-four hours beginning when they were elongated buds. I measured the nectar quantity (mg of sugar), flower length (mm) and nectar concentration. In addition to nectar measurement, a total of eight censuses were done every three days to count the total number of flowers per plant produced over the 2018 flowering season

Pivotal results. Dusted *I. aggregata* flowers were shorter than undusted flowers and produced less nectar. These two findings may be related since flower size and nectar production were positively correlated.

Conclusion. There are some factors that could have caused variation in the data. Two mechanisms are discussed, which refer to the quantity of nectar such as water limitations and bud's morphology when enclosed in the straw.

Keywords: *Ipomopsis aggregata*, Nectar production, Dusted vs Non-Dusted plants, Morphology

Introduction

Dust can cause substantial impacts on ecosystems that range from individual plants through local and regional scales to a global scale (Field et al, 2010). Dust responses can become interdependent with changes in climate and land use (Field et. al 2009). For example, plants growing along unpaved roads reduces their plant biomass (Sharifi et al, 1997). This leads for fields to be more erosive and interconnected (Field et. al, 2010). Road dust affects more than just the plants biomass, but it also interferes with stomata functions, increase leaf temperature, and reduce photosynthesis (Thompson et all, 1984).

In a recent study conducted, Waser, et al. (2017) found that in 19 of 20 independent tests wildflowers reduced stigma pollen loads in dusty conditions. Although, the number of seeds per flower did not vary consistently as a function of hand dusting treatments. Most of these tests included *Ipomopsis aggregata*. Waser, et al. mention four possible mechanisms that might contribute to the different effects of dust on pollen load and seed set: pollen grains on many stigmas were in excess needed for maximum seed set, the excess pollen in undusted plants was of low quality, pollen loads may limit the ability of plants to fill seeds, or a compensatory herbivory lay eggs on flowers that would ultimately reduce seed sets.

In the summer of 2018 at the Rocky Mountain Biological Laboratory, I conducted an experiment with *I. aggregata*, in two treatments: “dust” from unpaved roads and “undusted.” This study will focus specifically how dust from unpaved road could interfere with nectar productivity, affecting with pollination success. It is not known why dust, (primarily from unpaved roads) reduce pollen but one hypothesis is that dust decreases the cues for pollinators and/or the reward (=nectar). Together these would decrease hummingbird visits and thus

reduce pollen loads. The less nectar is produced, the less likely pollinators would return to the same plants, resulting a negative effect on the amount of pollen that is deposited and removed from the plant (Mitchell & Waser, 1992). If dusting causes plants to be less attractive then comparing nectar productivity with dusted verses non-dusted, dusted productivity would be less.

Materials and Methods

Study Site

The study was conducted at the Rocky Mountain Biological Laboratory (RMBL), in Gothic, Colorado. The study site was located at Maxfield Meadow, (106°59' 26.5666"W, 38°56' 57.8" N) one kilometer South of Gothic (Figure 1). All the measurements of nectar productivity and the total number of flower per plant were completed in Maxfield Meadow.

Making Pairs

To study the effects of road dust on *I. aggregata*, I selected 23 pairs of plants matched by the number of buds per plant, plant height, and location in Maxfield Meadow (County Road 317). The paired plants were randomly determined which plant within the pair was going to be dusted, by flipping a coin. Afterwards, each plant was given an ID to indicate which pair it belonged to and which treatment it received. Since County Road 317 was treated with the dust-suppressant magnesium chloride, the flowers were dusted manually. A hand duster (Spray doc, Gilmour Gardening Innovations) was used to dust the plants by hand. I collected dirt from the road north of Gothic that had not been treated with magnesium chloride (the "Dusty Corner" site). I sieved the collected dirt until it was a fine powder using a USA standard testing sieve (NO. 60). Plants receiving the dust treatment were dusted with ten puffs of the duster every

other day. Dusting ten times deposits quantities of dust particles similar to normal near-road conditions (D. Lopez & C. Rosas, RMBL 2017 student published). The dusted plants were pumped with dust, non-dusted plants were temporarily covered with a paper bag to prevent deposition of dust on the flowers. To control for any non-dust effects of the dusting process, the dusted treatment was mimicked by pumping non-dusted plants with a duster containing no dust.

Measuring Nectar

I measured the quantity of nectar produced by dusted and non-dusted flowers using a standard nectar collection method for *I. aggregata* (see Campbell et al. 1991). Elongated buds from dusted and non-dusted plants were selected to measure nectar, flower length in millimeters and the nectar volume in microliters. A drinking straw was placed over the entire bud and secured with a small wire. Placing a straw over the flower prevents pollinators from removing nectar. After twenty-four hours, I removed the straw and used a thirty-two-millimeter micro capillary to extract the nectar from the flower, and to quantify its volume (μl). Using a refractometer, the concentration of sucrose was measured and recorded. A total of ninety-one flowers of dusted and non-dusted plants were used to measure the nectar productivity of *I. aggregata* and between one to three plants were samples per plant. The flower length was measured from the base of the receptacle to the deepest cleft of the petal lobe.

Census

To assess energy investment by *I. aggregata* plants in flowering, each plant was censused every three days. The average floral lifespan of this species is about 3-5 days

(Campbell 1989; Waser 1978) and I wanted to capture all floral investment. For the census, the elongated buds, reflexed flowers, and fresh stigmas on each flower were counted for each plant. Damaged elongated buds, and reflexed flowers were marked as well and recorded for every census. I marked counted buds and flowers with a census-specific color, using a paint pen, to avoid recounting in a future census. A total of eight censuses were conducted beginning June 16th, 2018 and ending July 7th, 2018.

A total of ninety-one flowers was used to measure nectar quantity and flower length on each plant. However, nine of dusted and non-dusted flowers were not used for the analysis due to the flower being damaged or not producing enough nectar that could be read by the refractometer. Of the flowers collected, I calculated the mean value for flower length and nectar production. I used the flower means in the analysis and figures.

Results

Dusted flowers were 1.1mm shorter than undusted flowers on average (21.5mm vs 22.6mm). Flower length was not correlated with plant size as measured by total flower number- it occurred across plants of all sizes in the study (Figure 2).

Dusted flowers produced about 10% less sucrose than undusted treated plants (Figure 3). Flowers of dusted plants produced an average of 0.49 mg of sucrose compared to the undusted flowers which produced an average of 0.54 mg of sucrose. Total sugar content in mg volume was positively correlated with flower length (correlation coefficient $r = + 0.6121$; Figure 4). This demonstrates that the quantity of nectar produced is influenced by the length of a flower.

Flower length was weakly negatively correlated with the presence of dust (correlation coefficient $r = -0.03371$) and flower length was weakly positively correlated with nectar productivity ($r = +0.06121$; Table 1). Total flower number and flower were weakly correlated ($r = +0.0606$). Dust did not have a moderate positive relationship with total number of produced ($r = +0.1238$). Finally, total flower number had a moderate positive relationship with the quantity of nectar ($r = +0.2087$).

Maxfield Meadow



Figure 1- Maxfield Meadow Site, 1km South Gothic

Interaction of Flower Length vs Total Flower Number

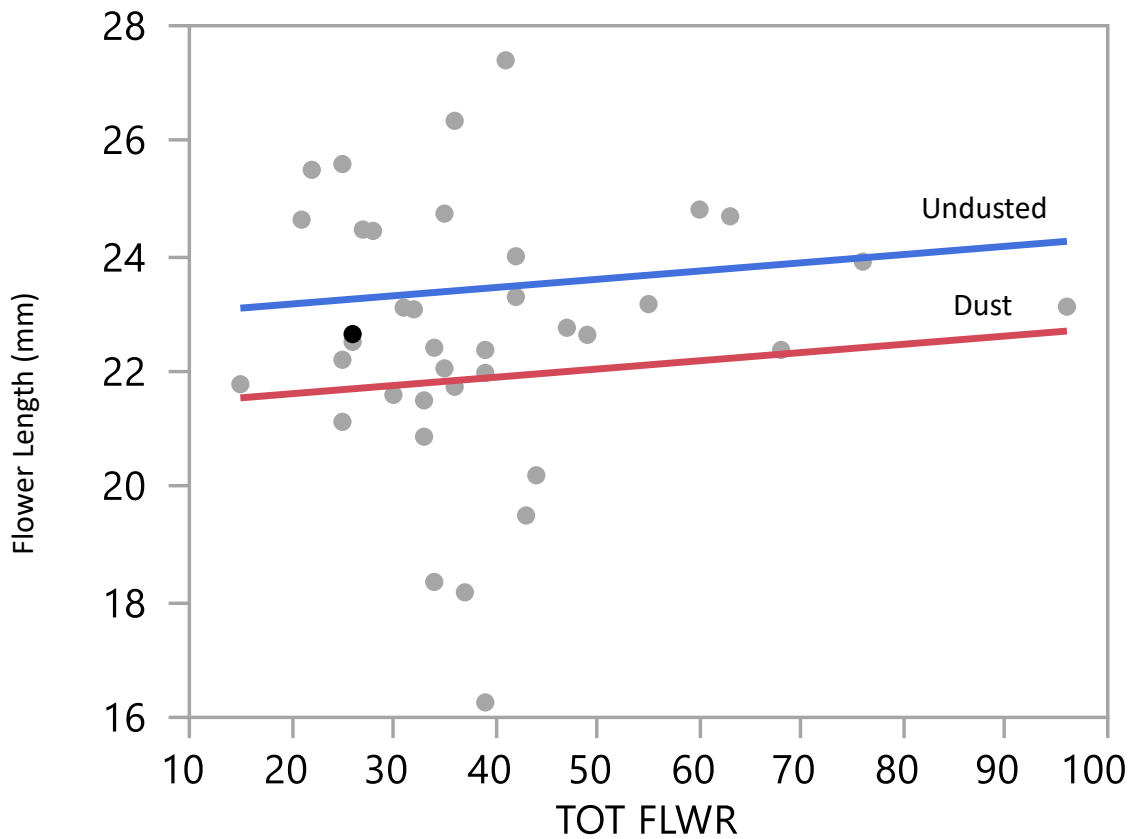


Figure 2. Dusted plants produce shorter flowers. There is no strong relationship between flower number and flower length.

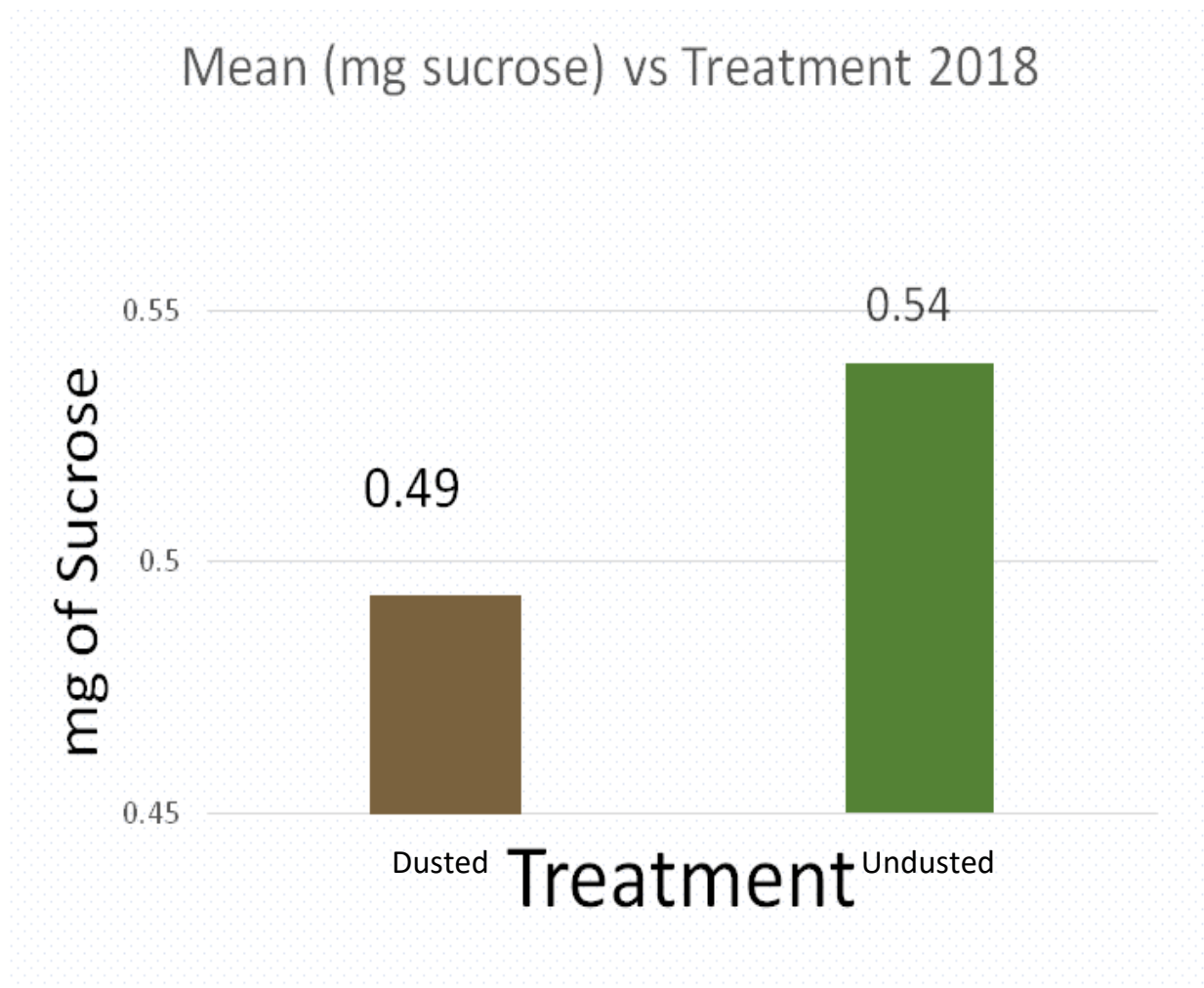


Figure 3. Dusted flower produced about 10% less sucrose than undusted flowers.

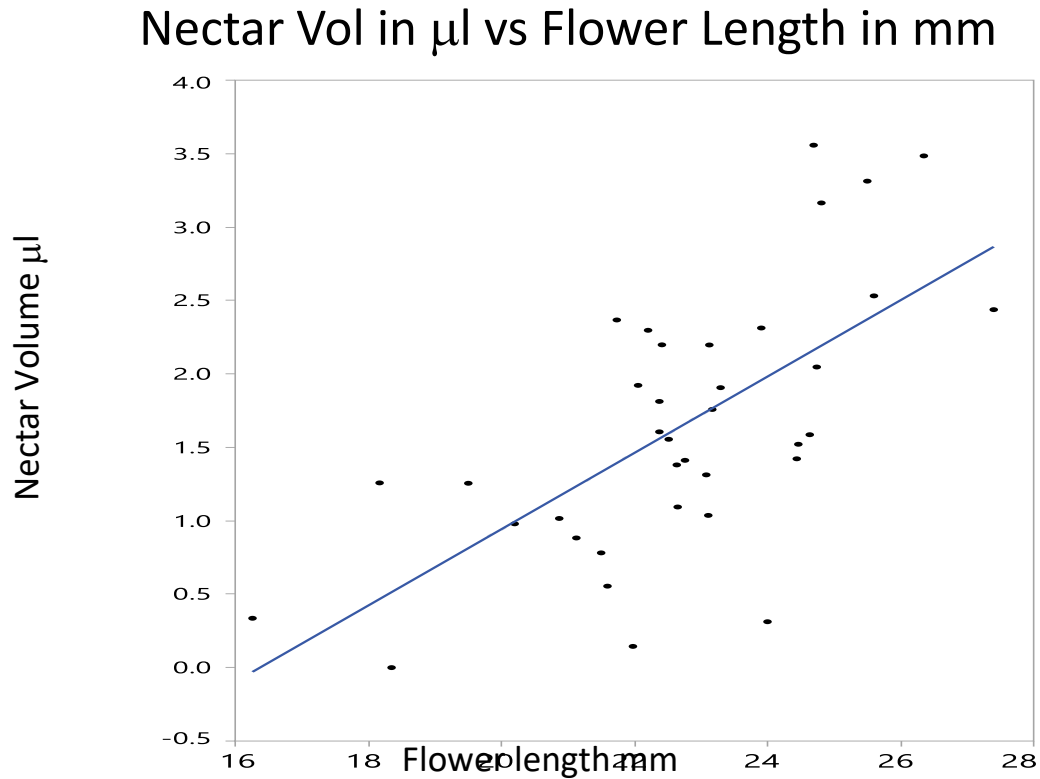


Figure 4. The quantity of nectar is influenced by the length of the flower.

The Correlation Coefficients between measured variables

	Total Flower number	Flower length	Dust
Nectar Quantity in mg sucrose	0.0185 p=.9559	+0.06114 p= -.0001	-0.0734 p=.6082
Flower length in mm	-0.0287 p=.8792	-	-0.3372 p=.0381
Dust	0.1942 p=.2237	-	-

Table 1. The correlation coefficients between measured variable (based on plant means) response variables. *Dusting treatment was scored as +1 for dusted plants and 0 for undusted plants. Dusting plants decreases flower length, and

flower length has a positive effect on nectar quantity involving the total flower number.

Discussion

In effort to see the effects of dust on nectar productivity, a series of flowers were collected to measure nectar, which resulted dust has an indirect effect on the amount of sucrose produced. From the results, we were able to make two conclusions. First dusted plants decreased flower length, and secondly, flower length has a positive relationship on the flower length on *I. aggregata*.

My preliminary results indicate that an abiotic environmental factor such as dust from unpaved roads can indirectly influence nectar productivity. Waser et al. (2017) found that in 19 of 20 independent tests wildflowers reduced stigma pollen loads in dusty conditions. Which may suggest dust of unpaved roads could interfere with nectar productivity, affecting with pollination success. In previous summers, other students have been able to explore furthermore the effects of dust in the morphology of *I. aggregata*, which may have an impact on nectar productivity. For instance, David Lopez looked at the longevity of an open flower among dusted and non-dusted plants. He discovered dusted plants tend to close their stomata sooner than non-dusted plants. So far, we know three things dust has been able to affect the morphology of *I. aggregata*: 1) flowers close their stomata sooner 2) nectar productivity is lower 3) the flower length is smaller.

Future studies that could help to better understand how road dust influence *I. aggregata* is to measure photosynthesis rates between the dusted and non-dusted plants could explain dust flowers having less nectar. Dust reduced plant photosynthesis rates so plants make

less sugar. Another future study is to repeat Lopez study and the study I conducted this summer to see if there are any possible correlations with the amount of nectar the plant produces, with how long the stomata stays open. I would be interested to know if those flowers whose stomata's stay open longer produce more nectar and have longer flower.

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