

Single-visit pollination efficacy of *Psithyrus insularis* and *Megachile* on *Chamerion
augustifolium*

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Abstract

There are many types of pollinators, all of which have an effect on a plant's reproductive success. As the types of pollinators are variable, so are their effects on the plant. In this study, I estimated the single-visit efficacy of two different Colorado bees, *Psithyrus insularis* and *Megachile*, on *Chamerion augustifolium*, a common wildflower. Single-visit efficacy was measured by counting pollen deposition on stigmas from virgin flowers that had been visited by a bee. The proportion of heterospecific pollen deposited was found to be significantly less in *P. insularis* individuals than in *Megachile* individuals, making *P. insularis* the more effective pollinator.

Introduction

Angiosperms are a very diverse group of flowers that can vary in morphology, color, scent, and size. Many of their morphologies are complex and are therefore associated with specific types of pollinators. This idea of associating pollinators with certain floral morphologies is called pollinator syndromes. For example, Syrphid flies tend to visit shallow simpler flowers where the pollen is easily accessible and also show a preference for yellow flowers (Goulson and Wright, 1998). Although these characterizations are widely accepted, studies have shown that they are not always accurate. In a study done on *Iposmopsis aggregata*, a red, tubular flower associated with hummingbirds, Mayfield, et al. found that long-tongued bumblebees were more effective at pollinating than the hummingbirds (2001). Flowers are visited by a variety of insects, all of which may have different effects on the plant's reproductive success. Since pollination is a limiting factor in plant reproduction, it is important to investigate these pollinators' effects on reproductive success (Burd, 1994).

In the past, pollinator efficacy has been estimated by measuring pollinator visitation frequency and/or duration (Galen and Newport, 1987), both of which describe quantitative qualities of pollination. However, according to Stebbins' "most effective pollinator principle," since selection is a qualitative process, "floral characteristics will be molded by pollinators that visit it most frequently and effectively (Stebbins, 1970)." In this way, pollinator efficacy can be broken down into two components: the flower visitation frequency (quantitative) and the amount of compatible pollen transferred per visit (qualitative) (Mayfield et al., 2001). Together, these factors measure overall pollinator efficacy.

In this study, I qualitatively measured the single-visit pollinator efficacy of two common Colorado bees, *Psithyrus insularis* and *Megachile*. *P. insularis* is a workerless social parasite which lacks cobiculae, the pollen-gathering structures that are characteristic of other *Bombus* species (Michener, 2000). Bees in the genus *Megachile* are considered solitary bees, commonly known as "leaf cutter" bees (Michener, 2000). As my focal plant, I chose *Chamerion augustifolium*, commonly known as fireweed, a protrandrous racemic inflorescence that grows in areas of disturbance (Darrow, 2006). *C. augustifolium* reproduces both by seed and underground rhizomes and is pollinated by a variety of insects, including Hymenoptera, Lepidoptera, and Diptera (Darrow, 2006). By observing the

behaviors of *P. insularis* and *Megachile* individuals on *C. augustifolium*, I evaluated whether one pollinator's single visit was more or less effective than another's.

Methods

In five sub-alpine patches of *C. augustifolium* surrounding Rocky Mountain Biological Laboratory (RMBL), spaced at least 20 m apart, I randomly chose 20 plants with budding flowers. I removed all flowers that were already open and receptive to pollen and covered the entire raceme with a fine mesh bag. These procedures ensured that the stigmas would not have any pollen until visited by a pollinator. I tested my hypothesis by exposing virgin *Chamerion augustifolium* flowers to single visits by *Psithyrus insularis* and *Megachile*. Several days later, when bagged flowers became female-receptive, I removed the bags one and two at a time and waited for the targeted bees to visit. After each pollinator had left the experimental plant, I marked each flower that was visited with string and replaced the bag on the inflorescence. I returned to the site two to three days later to ensure fertilization had take place before excising the stigmas. Stigmas were mounted in the field on microscope slides in fuchsin jelly and pollen loads were counted in the lab (Standard procedure). Over my two weeks of observation, 28 *P. insularis* and 31 *Megachile* individuals were observed visiting 144 experimental plants. To assess the effects of pollinator type on first-visit pollen deposition, I used two dependent variables: amount of conspecific pollen and the proportion of heterospecific pollen on flower stigmas. I analyzed these variables using generalized linear mixed-effects models (GLMMs) in R. The counts of conspecific pollen were analyzed with Poisson error model and the proportion counts were analyzed with binomial errors. For all flowers visited, I analyzed the same dependent variables with GLMMs using the LMER statistical package for the R statistical programming language. To avoid pseudoreplication, I grouped data by plant number.

Results

Using a GLMM with Poisson errors, I found that there was no significant relationship between conspecific pollen deposition on first-visit flowers and pollinator type (Figure 1, $p = 0.134$). Total conspecific pollen deposited on all flowers did not depend on pollinator type (Figure 2, $p = 0.275$). I found that the proportion of heterospecific pollen deposited on a stigma for first-visit flowers was significantly greater for the *P. insularis* individuals (Figure 3, $p < 2 \times 10^{-16}$), using generalized linear mixed-effects model with binomial errors. For all flowers visited, pollinator type did not have a significant effect on the proportion of heterospecific pollen deposited (Figure 4, $p = 0.115$).

Discussion

There was no significant relationship between the total amount of conspecific pollen and pollinator type for first-visit flowers and all flowers. Without information on fruiting and seed set, this data may not be of much importance to us. This is because we do not know how much pollen it takes for the fireweed to have a successful fertilization. What should become the focus is the amount of heterospecific pollen that is deposited on the stigma, as foreign pollen can be

detrimental to a plant's reproductive success (Morales and Traveset, 2008). This foreign pollen is a problem because it can cause problems in pollination, like physical clogging (Morales and Traveset, 2008).

After comparing the proportion of heterospecific pollen between the two pollinator types, I discovered that *P. insularis* individuals are more effective pollinators, transferring a smaller proportion of heterospecific pollen to first-visit flowers than *Megachile*. This could be because, since *Psithyrus* are workerless social parasites and do not collect pollen to take away to the colony, the pollen that they pick up goes right back to the flowers. Also, these results could be explained by flight distance and flower constancy. Flower constancy is when a pollinating species restricts its visits to flowers of a specific species or morph, even if it bypasses an equally rewarding alternative in the process (Waser, 1986). It is important for an insect to show flower constancy because a pollinator that consistently visits the same species is able to transfer the appropriate type of pollen to each plant, which can result in a higher rate of cross-fertilization (Pyke, 1984). An inconstant flower pollinator has the tendency to remove pollen from a flower that could have been transferred to a conspecific plant, but is instead deposited on the stigma of the wrong flower species. Since *P. insularis* are larger than *Megachile*, it is possible that we can expect a longer flight distance, allowing the bee to remain more constant with its foraging fidelity. While the proportion for all flowers was not statistically significant for a given pollinator type, we saw a different trend in the data than in the first-visit flowers. *Megachiles* were found to be more effective in this model. I am not certain why we were seeing this difference between first-visits and the rest of the visits, but it could be that *Psithyrus* gets most of its pollen off at once and the *Megachiles* do not. Since the *Psithyrus* aren't packing their pollen in for collection, it may come off easier. Overall, *P. insularis* was the more effective single-visit pollinator because it transferred a smaller proportion of heterospecific pollen than *Megachile*.

To attain a deeper understanding of the relationships between these pollinators and *C. augustifolium*'s reproductive fitness, we plan to collect seed set from experimental first-visit flowers. Additionally, it would be interesting to investigate these relationships between other species of bumblebees and flowers in the future.

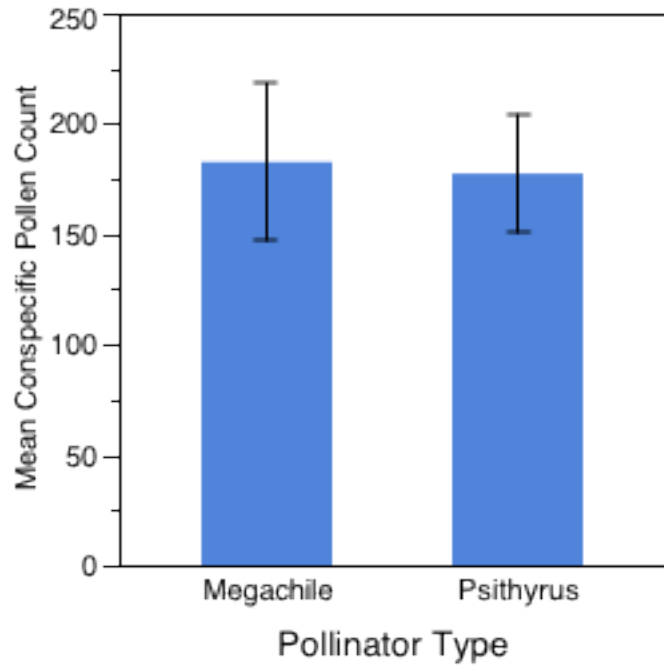


Figure 1 Mean count of conspecific pollen for *P. insularis* and *Megachile* for first-visit flowers ($p = 0.134$).

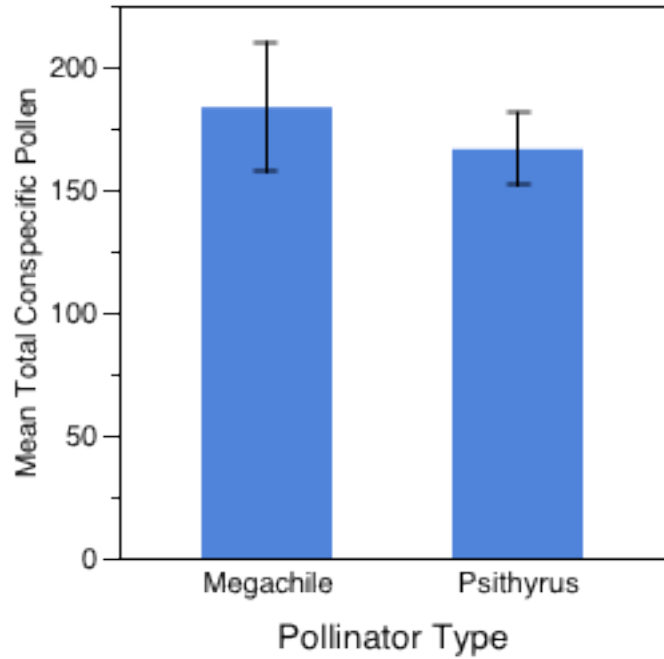


Figure 2 Mean count of conspecific pollen for *P. insularis* and *Megachile* for all flowers ($p = 0.275$).

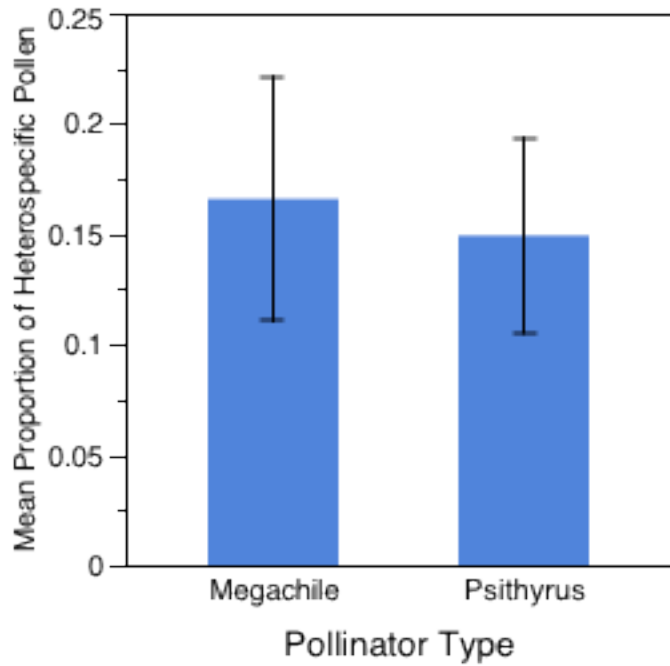


Figure 3 Mean proportion of heterospecific pollen deposition for *P. insularis* and *Megachile* for first-visit flowers ($p < 2e-16$).

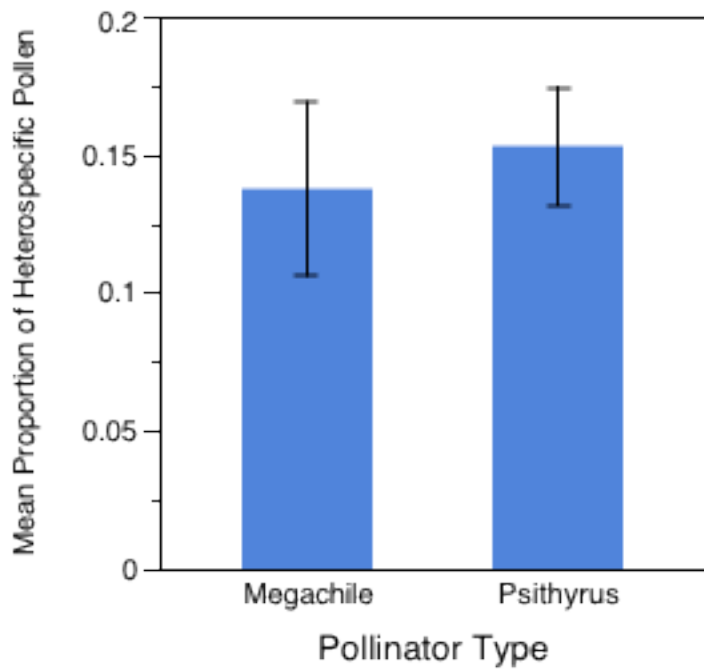


Figure 4 Mean proportion of heterospecific pollen deposition for *P. insularis* and *Megachile* for all flowers ($p = 0.115$).

Literature Cited

- Burd, M. 1994. Bateman's principle and plant reproduction-the role of pollen limitation in fruit and seed set. *Botanical Review*. 60:1 p. 83-139.
- Darrow, Katherine. *Wild about Wildflowers: Extreme Botanizing in Crested Butte Wildflower Capital of Colorado*. Fort Collins, CO: Heel and Toe, 1998. Print.
- Mayfield, M. M., N. M. Waser, and M. V. Price. 2001. Exploring the 'most effective pollinator principle' with complex flowers: Bumblebees and *Ipomopsis aggregata*. *Annals of Botany* 88: 591-596.
- Michener, Charles Duncan. *The Bees of the World*. Baltimore, MD: Johns Hopkins UP, 2000. Print.
- Galen, C., and M. E. A. Newport. 1987. Bumble bee behavior and selection on flower size in the sky pilot, *Polemonium viscosum*. *Oecologia* 74: 20-23.
- Goulson, D. and N. Wright. 1998. Flower constancy in the hoverflies *Episyrphus balteatus* (Degeer) and *Syrphus ribesii* (L.) (Syrphidae). *Behavioral Ecology*. 9:3 p. 213-219.
- Morales, C. and A. Traveset. 2008. Interspecific pollen transfer: Magnitude, prevalence, and consequences for plant fitness. *Critical Reviews in Plant Sciences*. 27:221-238.
- Pyke, G. 1984. Optimal foraging theory: a critical review. *Annual Review of Ecology and Systematics*. 15:523-575.
- Stebbins GL. 1970. Adaptive radiation of reproductive characteristics in angiosperms I: pollination mechanisms. *Annual Review of Ecology and Systematics* 1: 307-326.
- Waser, N. 1986. Flower constancy: Definition, cause, and measurement. *The American Naturalist*. 127:5 p. 593-601.