# Pollen deposition and handling time of European honey bees on seedless watermelon


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## INTRODUCTION

- **Pollinator performance** (also called *effectiveness* or *efficiency*) is a complex measure that evaluates the ability of an organism to pollinate a crop. These measures are becoming increasingly important with the emerging need for comparative studies of alternative crop pollinators (Ne'emen *et al.* 2009).
- A fundamental parameter of pollinator efficiency is **pollen deposition**, which can be measured as the amount of pollen a pollinator leaves on a flower's stigma in one visit.
- For cucurbit crops like watermelon, pollen deposition is typically measured using "virgin" female flowers, which are bagged with fine mesh netting before opening (Kremen *et al.* 2002). A single, initial visit by a pollinator is then allowed, and any pollen it leaves on the flower is quantified.
- The underlying assumption is that pollen deposition estimates from these initial visits are similar to those of all subsequent visits the female flower would receive over the course of the flowering period in nature.
- One reason why initial visits may differ from subsequent visits is that floral nectar levels consistently change throughout the day (Edge *et al.* 2011). It has been found that nectar levels in female flowers affect honey bee foraging behavior and pollen deposition.

## Questions

1) Are estimates of pollen deposition and handling time from initial visits to female flowers similar to those of all subsequent visits to the same flower?
2) Are pollen deposition and handling time influenced by the time of day when the bagged female flower is unbagged?

## Watermelon study system

- Monoecious: separate male and female flowers [Fig. 1]
- Flowers open around 7:00 a.m., close mid-afternoon (any given flower is only open for part of one day)
- A total of about 1,000 pollen grains needs to be brought to a flower's stigma by bees to produce a fruit (Kremen *et al.* 2002)

[Fig. 1] Male (left) and female (right) watermelon flowers.

## METHODS

- Site: Spadra Ranch at Cal Poly Pomona
- Timeframe: 27-29 July and 1-3 August 2011
- Flowers were bagged before they opened (5:45-6:30 a.m.); After opening, a flower was unbagged and presented at the end of a rod to a honey bee [Fig. 2]

[Fig. 2] After opening in the bag, female flowers were unbagged and these "virgin" flowers were presented for a bee to visit.

- Some flowers were presented to bees during the early morning (7:00 - 8:20 a.m.); other flowers were left bagged until the late morning (10:45 - 12:30 a.m.) before being presented to bees [Fig. 3]
- During both time periods, some flowers were allowed only one initial visit, while other flowers were allowed four consecutive visits from different honey bees [Fig. 3]

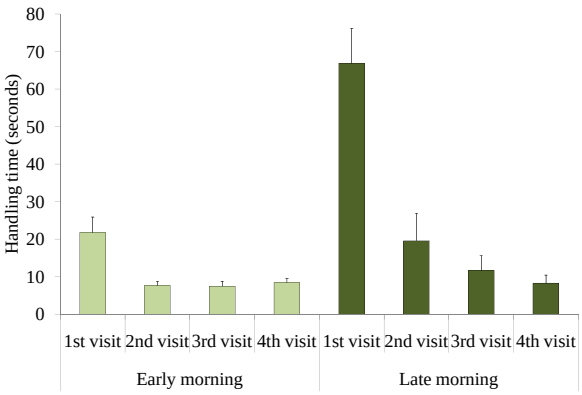
| | | Time of day | |
|---|---|---|---|
| | | early morning | late morning |
| Visit level | one visit | $n$ = 22 flowers | $n$ = 22 flowers |
| | four visits | $n$ = 21 flowers | $n$ = 20 flowers |

[Fig. 3] Experimental design and sample size, with two factors (time of day and visit level), each with two levels.

- **Data collection:** For each flower, the handling time of the visit(s) it received was recorded. The total amount of pollen deposited on the stigma and petals was determined using staining methods described in Kremen *et al.* (2002) and Winfree *et al.* (2007)
- **Data analysis:** Two-factor ANOVAs were performed on square root-transformed data

## RESULTS

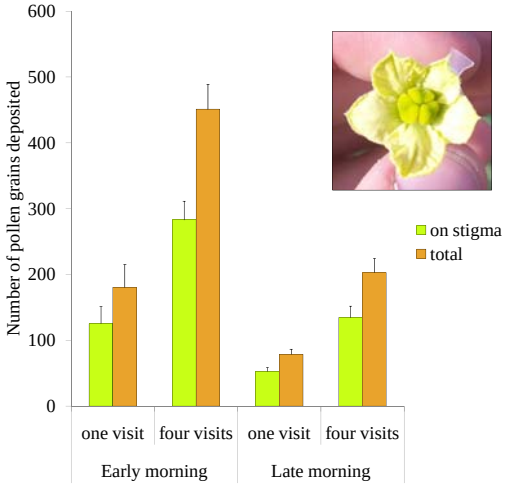
Handling time




[Fig. 4] Mean (± SE) handling times of bees on female flowers visited four times. Both the early and late morning time periods are shown.

- Initial visit handling times were 2-6 times longer than those of subsequent visits for both time periods ($F$ = 10.6, 24.9 respectively; $p < 0.001$ for both time periods) [Fig. 4]
- Initial visits in the late morning were 3 times as long as those in the early morning ($F$ = 58.7, $p < 0.001$) [Fig. 4]

Pollen deposition




[Fig. 5] Mean (± SE) pollen grains deposited by bees on female flowers after either one visit or four visits. Both the early and late morning time periods are shown.

- Pollen deposited by each subsequent visit was on average 50% of the amount deposited by the initial visit for both time periods ($F$ = 64.5, $p < 0.001$) [Fig. 5]
- Pollen deposition rates during the late morning were about half of those in the early morning ($F$ = 38.8, $p < 0.001$) [Fig. 5]
- A single visit in the early morning deposited a similar amount of pollen as four visits in the late morning (Tukey's HSD test $p > 0.05$) [Fig. 5]

## Discussion

- Lower pollen deposition rates in the late morning (despite longer handling times) were perhaps due to decreased pollen availability (Edge *et al.* 2011). Stanghellini *et al.* (2002) found over 60% of pollen is removed from male watermelon flowers within the first two hours of the male flowers being open.
- Longer handling times in the late morning may be due to higher availability of nectar. In many cucurbits, nectar is produced continuously in female flowers (Ashworth and Galletto 2002).

## Significance

- Standard measures of pollen deposition using initial visits do not appear to accurately reflect honey bee pollinator performance on watermelon. Pollen deposition values from initial visits are overestimates of values from subsequent visits by a factor of at least two.
- It would perhaps be better to measure pollinator performance based on non-initial visits, as these constitute the majority of visits a flower receives.
- In addition, time of day had a considerable effect on pollen deposition and handling time.
- The knowledge gained from this study will contribute to a better understanding of pollinator performance comparisons between honey bees and alternative native bee pollinators.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