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 to 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)

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]

RESULTS

<table>
<thead>
<tr>
<th>Time of day</th>
<th>Visit level</th>
<th>Number of pollen grains deposited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early morning</td>
<td>one visit</td>
<td>22 flowers</td>
</tr>
<tr>
<td>Early morning</td>
<td>four visits</td>
<td>21 flowers</td>
</tr>
<tr>
<td>Late morning</td>
<td>one visit</td>
<td>22 flowers</td>
</tr>
<tr>
<td>Late morning</td>
<td>four visits</td>
<td>20 flowers</td>
</tr>
</tbody>
</table>

[pollens deposited by bees on female flowers visited four visits]

- 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]
- 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

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 has 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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