Contributions of native, unmanaged bees to pollination of pumpkin and squash in Ohio and correlates to their densities

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Introduction

- I investigated the contribution of native unmanaged pollinators to squash and pumpkin pollination on farms in Ohio and factors influencing pollinator foraging densities. In this area, >40% of growers reported inadequate pollination in some years.
- Pumpkins and squashes (*Cucurbita*) require bees to transfer pollen from male flowers to female flowers. Honey bees (*Apis mellifera*) are most commonly used in commercial settings, but unmanaged, native bees also can contribute to pollination of crops (1).
- Continuing stress on honey bees has threatened their populations and increased the cost of pollination services (2). Documenting the services of unmanaged native bees and factors that control their density will facilitate their use in agricultural systems (3).
- Before growers can rely on native bees, they need to know which species are available on their farms, their effectiveness at pollination, and minimum densities to adequately pollinate their crops.
- Factors such as pesticide use, tilling practices (4), and availability of suitable habitat (5) have been shown to influence bee diversity and population density.
- The cucurbits are of special interest because they are pollinated by several species of native specialist bees (6), as well as native and non-native generalist bees.

Questions

- What is the composition and density of pollinators on squash and pumpkin cultivars in south central Ohio?
- How does bee density on flowers vary with farm management practices such as tilling and irrigation?
- How does pollinator density affect pollen transferred to stigmas?
- How many bees are needed for full pollination and yield?

Hypotheses

- o Native squash bees (*Peponapis pruinosa*) are the most abundant pollinator (4, 7, 8).
- o Tilling inhibits squash bees by disrupting nests excavated in fields (4).
- o Irrigation improves floral rewards to the benefit of all bee species. It may also facilitate excavation by ground-nesting squash bees by softening the soil .
- o Pollen deposition on stigmas should increase with foraging bee densities.
- o 1500-2000 pollen grains, or >15 visits are needed for maximum yield in pumpkins (7), which can be done by native bees alone (4).

Methods

- Censused bees and flowers on small to mid-sized commercial squash and pumpkin farms over 2 years: 2005 (n=12 farms), 2006 (n=12, 3 new to survey) (Plate 1).
- 300 flowers (or all flowers) were surveyed for 15-90 min once during peak bloom between 0630-0900 on fair weather days.
- Stigmas of day old flowers were collected to count pollen grains deposited during open pollinated conditions.
- Other variables recorded:
  - Tilling (till/no till, and depth in cm)
  - Irrigation (yes/no)
  - Other flowering crops attractive to bees (yes/no)

Plate 1. A small, multi-crop produce farm with cucurbits and untilled field margins.

Plate 2. A squash maturing in a field

Results: bee foraging densities and composition

- In both years *Peponapis pruinosa* (Plates 3, 4) was the most abundant visitor to cucurbit flowers ($p = 0.001$), comprising nearly 50% of all visitors overall (Fig 1). *Peponapis* was absent from only 2 farms, both of which had the species in one of two years.
- *Bombus* (Plate 5), *Apis*, and other bees (e.g., Plate 6) were similar in abundance across farms (Fig 1).
- *Apis* were absent from cucurbit flowers at 9 different farms, 6 of which had at least 1 hive and two of which had apiaries of > 15 hives.
- Hotter, drier weather in 2006 likely promoted bee abundance in 2006 ($p = 0.06$) (Fig1).

Plate 3. Female *Peponapis pruinosa* on pumpkin

Plate 4. *Peponapis pruinosa* male

Plate 5. *Bombus* worker on squash

Plate 6. *Melissodes bimaculata*

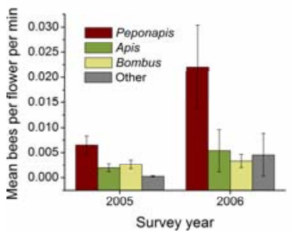

Figure 1. Mean numbers of bees per flower per minute of observation. Error bars are standard errors.

Results: Correlates to bee density

- Irrigated fields harbored nearly four times as many *Peponapis* as non-irrigated fields, but densities of other species were similar ($p < 0.01$). (Fig. 2a)
- All but 2 fields studied were tilled. Till depth (0 - 46 cm) had no significant effect on the density of any bee species ($p > 0.05$, not shown).
- Untilled field margins were associated with higher densities of *Peponapis* ($p = 0.03$). *Apis* and *Bombus* did not differ between farms with tilled and untilled margins (Fig 2b).
- Fields with tilled margins typically bordered large corn and soybean fields, which offer few floral resources and are intensively managed.

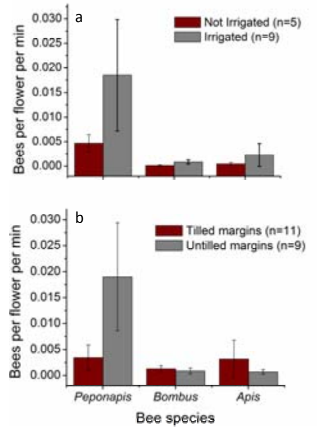

Figure 2. Mean bee densities per flower per minute as a function of farm management practices: a) irrigated vs. not irrigated and b) tilled margins vs. untilled margins. Error bars represent standard errors. Means were taken over years across sites. Some farms had more than one observation if fields were separated or different cultivars had distinct blooms.

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Results: how many bees are enough?

- Foraging density of all bees explained 73% of the variance in mean pollen deposition and *Peponapis* alone explained 49%, indicating its importance in pollen movement (univariate regressions, Figs 3a, b).
- On average, all farms received adequate pollen to set marketable fruit (> 2000 grains).

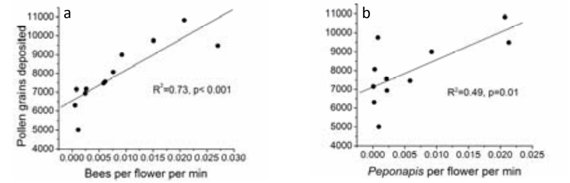

Figure 3. Mean number of pollen grains per stigmas as a function of bee foraging density shown for farms sampled in 2005. a) densities of all bees combined, b) densities of *Peponapis pruinosa* only. Solid lines represent linear fits and R^2 values were generated with linear regression. N = 1 – 10 stigmas per field.

- Using an estimate of 150 grains deposited per visit (7), 10 visits are required to maximize pumpkin fruit set and ≥ 15 visits per flower to maximize fruit and seed mass (8).
- Predicted lifetime visits of flowers in 4 fields had a > 50% chance of receiving full pollination at either the 10- or 15-visit level for all bees or native bees alone (Figs 4a, b). Model details in Fig 4 caption.

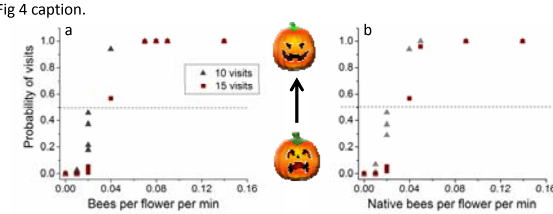

Figure 4. The expected probability of receiving 10 or 15 visits over a 7 hr floral lifetime was predicted using a Poisson distribution of visits to flowers with the observed mean foraging density. Calculated separately for a) all bees and b) native bees alone.

Conclusions

- **Native, specialist squash bee, *Peponapis pruinosa,* has the highest foraging density (Fig. 1) and is responsible for nearly 50% of pollen transported** in squash and pumpkin (Fig 3).
- **Squash bees respond positively to irrigation and untilled field margins**, but not till depth. The mechanism may be related to nesting substrate because *Apis* and *Bombus,* which do not nest in fields, show no response (Fig 2).
- **The predicted lifetime bee visitation per flower falls short of that needed for full pollination** and maximum yield on most farms (Fig. 4), despite large mean pollen loads on (Fig. 3).
- **Supplying more honey bee hives is unlikely to improve pollination** during peak bloom because even farms with large apiaries had low foraging densities of *Apis* (Fig 1). The most economical option appears to be employing management practices that promote native bees.

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