Where have all the pollinators gone?

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What exactly is pollination anyway?

WHY CARE ABOUT BUMBLEBEES?
Ecosystems depend on pollination services
Insect pollinators contributed **29 billion dollars** to US agriculture in 2012

Figure 1. Historical estimates of the value of honey bees to US agriculture.
What exactly is happening to bumblebee population levels?

Cameron et al. 2011
Depressing things....

B. bifarius

B. bimaculatus

C

F

A
Depressing things....
... but not for all
An open question

POTENTIAL CAUSES
Bumblebee life history makes their populations vulnerable to changes in resource acquisition
Bumblebees have an annual life cycle
The colony produces reproductives, and the newly mated queens head into hibernation.
How well colonies forage has a dramatic impact on fitness – and therefore local population levels.

Fig. 2. Size-dependent reproductive success of *B. lucorum* colonies. Colony size is the maximum number of workers we observed during night checks. Dots (·) indicate the number of colonies in each group that have suffered *Psithyrus bohemicus* invasions.
What is causing declines?

- Parasitic Infections (mites)
- Bacterial disease load
- Pesticide exposure
- Habitat fragmentation
Neonicitinoid pesticides lower foraging efficiency\(^1\) & reduce bumblebee queen production\(^2\)

**Fig. 2.** The number of new queens produced by the control colonies was greater than the number produced in both low- and high-treatment colonies. Bars represent the mean number of queens and their standard errors. Asterisks indicate significant differences.

\(^1\)Gill et al 2012

\(^2\)Whitehorn et al 2012
What is causing declines?

? Parasitic Infections (mites)
? Bacterial disease load
? Pesticide exposure
? Habitat fragmentation
Indirect effects of agrochemicals on bumble bee behavior

WHAT WE DO
What are the behavioral effects of agrochemical contamination?

1. Do agrochemicals modify bumblebee ability to locate resources using olfactory cues?

2. Does agrochemical chemical contamination modify bumblebee willingness to feed upon a learned resource?
What are the behavioral effects of agrochemical contamination?

1. Do agrochemicals modify bumblebee ability to locate resources using olfactory cues?

2. Does agrochemical chemical contamination modify bumblebee willingness to feed upon a learned resource?
Bees were trained to a linalool-scented feeder

Sprayberry et al 2013
Control: foraging chamber replaced with an unpolluted maze

Variables recorded:

• First Chamber Choice Accuracy
• Time to Feeder
Turf Builder: maze permeated with fertilizer

Variables recorded:

- First Chamber Choice Accuracy
- Time to Feeder
Manzate: maze permeated with fungicide

Variables recorded:

- First Chamber Choice Accuracy
- Time to Feeder
Bumblebees are able to locate feeder in all conditions

- Control: n = 9
- Turf Builder: n = 7
- Manzate: n = 10
Performance is poorer in Manzate mazes

- Control: n = 9
- Turf Builder: n = 7
- Manzate: n = 10
Bumblebees take longer to find feeder in the Manzate maze

![Bar chart showing time to feeder (min) for Control, Turf Builder, and Manzate conditions. The Manzate condition has a significantly higher time to feeder compared to the other conditions with p<0.001.]
What are the behavioral effects of agrochemical contamination?

1. Do agrochemicals modify bumblebee ability to locate resources using olfactory cues?
   - Manzate negatively impacts *Bombus impatiens* olfactory-navigation performance

2. Does agrochemical chemical contamination modify bumblebee willingness to feed upon a learned resource?
What are the behavioral effects of agrochemical contamination?

1. Do agrochemicals modify bumblebee ability to locate resources using olfactory cues?
   - Manzate negatively impacts *Bombus impatiens* olfactory-navigation performance

2. Does agrochemical chemical contamination modify bumblebee willingness to feed upon a learned resource?
What role does preference play?
What role does preference play?
Bees were trained to a linalool-scented feeder
Bumblebees allowed to choose between foraging chambers with different environmental conditions

Number of Bees on Feeder

<table>
<thead>
<tr>
<th>No pollution</th>
<th>Manzate</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
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<td>...</td>
<td></td>
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</tbody>
</table>
Bumblebees prefer to feed in uncontaminated environments.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Average # of bees (15 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>control</td>
<td></td>
</tr>
<tr>
<td>control</td>
<td></td>
</tr>
<tr>
<td>turf builder</td>
<td></td>
</tr>
<tr>
<td>control</td>
<td></td>
</tr>
<tr>
<td>manzate</td>
<td></td>
</tr>
</tbody>
</table>

- **control**: $p = 0.45$
- **turf builder**: $p = 0.01$
- **manzate**: $p = 0.02$
What are the behavioral effects of agrochemical contamination?

1. Do agrochemicals modify bumblebee ability to locate resources using olfactory cues?
   – Manzate negatively impacts *Bombus impatiens* olfactory-navigation performance

2. Does agrochemical chemical contamination modify bumblebee willingness to feed upon a learned resource?
   – Bumblebees are less likely to feed in an environment with agrochemical contamination
Agrochemicals are likely modifying foraging patterns.

Floral Odor + Agrochemicals

Location of Flowers

Flight Path Modulation

Olfactory Processing
Power of the consumer

WHAT YOU CAN DO
Help locate bumblebees in our area!

• Foraging surveys
  – Where do you see bumblebees?
  – How many do you see?
  – What plants are they on?
Help locate bumblebees in our area!

• Foraging surveys
  – Where do you see bumblebees?
  – How many do you see?
  – What plants are they on?

• *Effects of patch size*
• *Effects of fragmentation*
• *Abundance*
Help locate bumblebees in our area!

• Foraging surveys
  – Where do you see bumblebees?
  – How many do you see?
  – What plants are they on?

• **Emerging technologies integration: build your own wearables**
ACKNOWLEDGEMENTS

It takes a village

Muhlenberg College

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