UMass Extension

Sunflower Pollen and Bee Health

Research from the Adler Lab at UMass

Wild bee populations have declined over the past century for many reasons, including habitat loss. Industrial farming as well as urban and suburban development have created landscapes with fewer flowers and less undisturbed areas for nesting. **Exacerbating the harmful effects of habitat loss for bees are pesticides, climate change, invasive species, and - most important to our story - disease.** (Read more about bee declines here.)

The best way to help bees is to plant flowers. While any flowers are better than none, researchers are currently working to understand the best plant combinations for pollinators.

To this end, Dr. Lynn Adler and her lab at UMass Amherst study how different flowers affect bee diseases. **In 2015, they fed sunflower pollen to sick bumble bees and found that it dramatically reduced infections of a common gut parasite.** They've since conducted numerous experiments to learn how sunflower and related plants impact bee health. Their goal is to understand the value of sunflower as part of a diverse floral mix.

This fact sheet explains their research findings.

So...should you plant sunflowers to help bees?
YES! *But don't forget to plant other flowers as well, to provide a diverse diet for your local pollinators. Continue reading to learn more.*

AT A GLANCE:

1. Main finding

Common eastern bumble bees *(Bombus impatiens)* fed sunflower pollen had reduced levels of a ubiquitous gut parasite (*Crithidia bombi*).

2. Does it work outside the lab?

- Wild *B. impatiens* gathered from farms with more sunflower had lower *Crithidia* infection levels.
- *B. impatiens* colonies placed on **farms with more sunflower** had less *Crithidia* and reproduced more than colonies on farms with fewer sunflowers.

3. How broad is this effect?

- Pollen from many plants in the sunflower family also reduced *Crithidia* infections, including **goldenrod**, a distant relative.
- Sunflower pollen did not reduce *Crithidia* as dramatically in other bumble bee species.
- Sunflower reduced *Crithidia* in *B. impatiens* **queens and workers** but not drones.
- A **50% sunflower diet** also reduced *Crithidia*.

4. Why do we see this effect?

Sunflower pollen does not reduce *Crithidia* via a chemical mechanism; rather it appears to disrupt the parasite via its **spiky outer coating**. Many related plants also have spiky pollen.

TAKE-AWAY:

- **Eating sunflower pollen** (and pollen from related plants like goldenrod) **may reduce infections of a pervasive gut parasite in the common eastern bumble bee**. This species is not in decline, but it is quite common, so may spread diseases to other species.
- However, sunflower is relatively low in protein, so is best for bees as part of a **diverse wildflower planting.**
- **For more info on planting for bees, click here.**

For more detailed info about this research, read on!

More about Bumble Bees, Bee Disease and Sunflowers

The Adler Lab uses the model system of the common eastern bumble bee and their ubiquitous gut parasite Crithidia bombi *to answer questions about how pollen chemistry and shape affect bee disease.*

The Bee: Common Eastern Bumble Bee (*Bombus impatiens*)

B. impatiens *foraging on an eggplant flower, Photo: H. Whitehead*

The common eastern bumble bee is native to many parts of Eastern North America. Unlike most wild bees, bumble bees live in social colonies. Each colony is founded in the spring by a queen bee. She searches for a ground cavity, such as an abandoned rodent burrow, in which to establish her nest. She then lays eggs and provisions them with pollen and nectar. The colony grows to several hundred individuals over the summer. Most of the bees are female workers. Towards the end of the summer, the queen starts producing males and reproductive females (daughter queens) that leave the nest and mate. In the winter, the colony dies, and only the newly mated queens overwinter underground.

Unlike many native bees, the common eastern bumble bee is not in decline. In fact, populations have been increasing. However, it is an ideal organism to study because it is reared commercially for greenhouse pollination so can be purchased easily and maintained indoors. Colonies can also be reared in the lab from wild-caught bees. In addition, this bee is important because it is very abundant and likely transmits diseases to other bees.

A lab-reared bumble bee colony, Photo: R. Malfi

The Disease: *Crithidia* (*Crithidia bombi*)

Crithidia bombi, Photo: Boris Baer

Crithidia bombi is a gut parasite of bumble bees. *Crithidia* is a protozoan pathogen that lives in bee intestines and is transmitted through feces in the colony or on flowers.

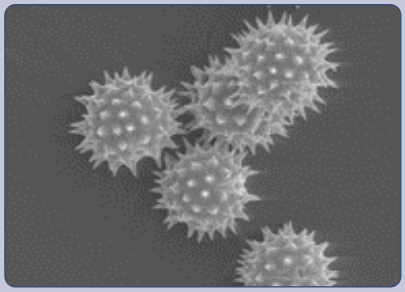
Studies find that it is ubiquitous among bumble bees in Massachusetts. It reduces bumble bee longevity, learning, foraging and queen hibernation. It is useful to study because it is widespread and can be easily maintained in a lab.

The Plant: Sunflower (*Helianthus annuus*)

Bees pollinating a sunflower, Photo: H. Whitehead

Sunflowers are native to North America and their yield is improved by bee pollination. They are cultivated worldwide for their oil; in 2018, there were over 1.2 million acres of sunflower planted in the United States. Sunflower pollen is relatively low in protein, so bees fed exclusively sunflower have smaller larvae and shortened lifespans. However, when bees eat 50% sunflower pollen mixed with pollen from other flowers, they live as long as bees fed non-sunflower pollen.

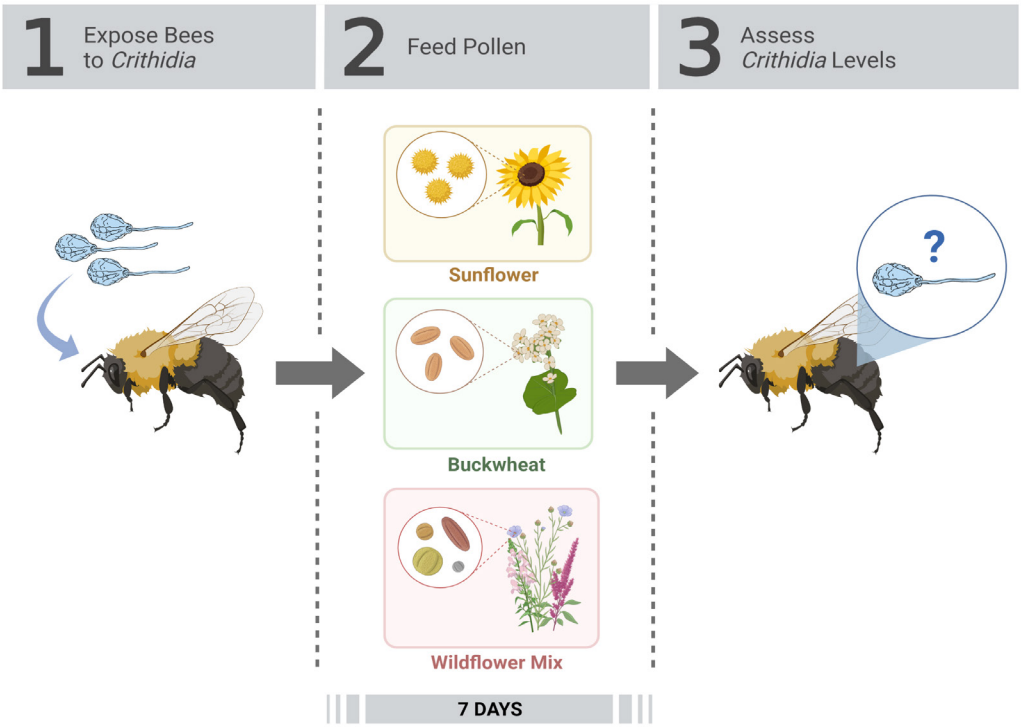
Sunflower pollen is notable because it has a spiky exterior, like pollen from many plants in the same family.



Sunflower pollen, refm.dartmouth.edu

Experimental Methods

For all lab experiments, bumble bees were exposed to Crithidia*, fed different pollen diets, and then dissected to assess* Crithidia *levels. Figure 1 (below), shows the experimental method for Giacomini et al. 2018 (main finding, below).*



Results

1. MAIN FINDING

Sunflower pollen dramatically reduced *Crithidia bombi* in both wild and commercial *Bombus impatiens*.

After exposing bees to *Crithidia* and feeding them different pollen diets (see Figure 1), Adler Lab researchers consistently found that bees fed sunflower pollen had dramatically lower levels of *Crithidia* than bees fed buckwheat or wildflower pollen. Because buckwheat pollen, like sunflower pollen, is low in protein, the researchers also concluded that sunflower's low protein is not the reason it reduced *Crithidia*.
Read the full paper here.

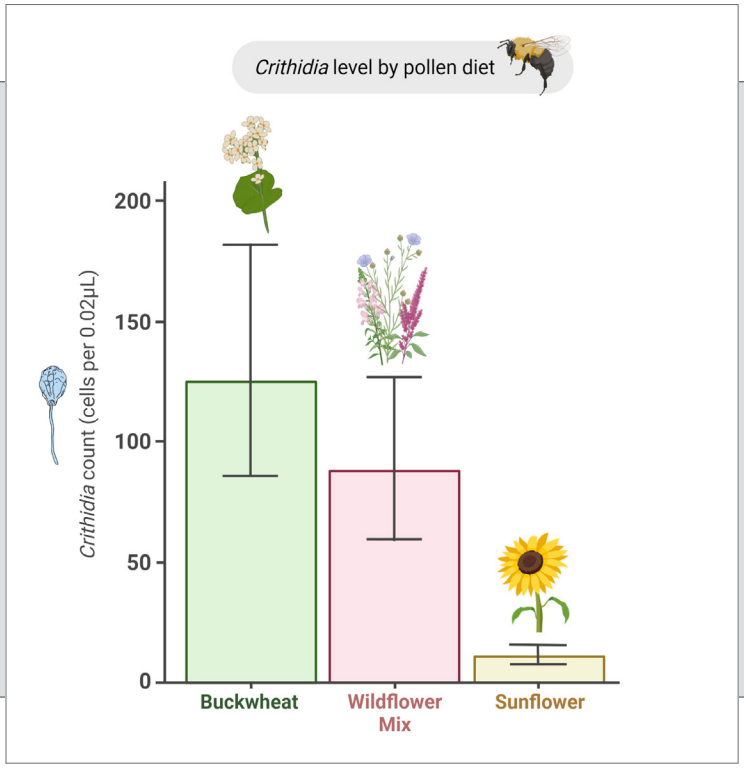


Figure 2. Bees fed a sunflower pollen diet had significantly lower Crithidia *counts than bees fed buckwheat or a wildflower mix. Adapted from Giacomini et al. 2018.*

2. DO WE SEE THIS EFFECT OUTSIDE THE LAB?

Yes! Bumble bees on farms with more sunflower had less *Crithidia*.

In 2015, researchers gathered wild bumble bees from farms around the Pioneer Valley. They measured the area of sunflowers grown at each farm and assessed the bees' *Crithidia* infection. They found that bees caught on farms with more sunflower had lower infection. Read the full paper here.

In 2019, researchers placed commercial bumble bee colonies on Pioneer Valley farms with varying amounts of sunflower. At the end of the experiment they assessed colony growth and *Crithidia* infection. They found that colonies placed on farms with more sunflowers had less *Crithidia* and reproduced more than colonies on farms with fewer sunflowers. Malfi et al., in prep.

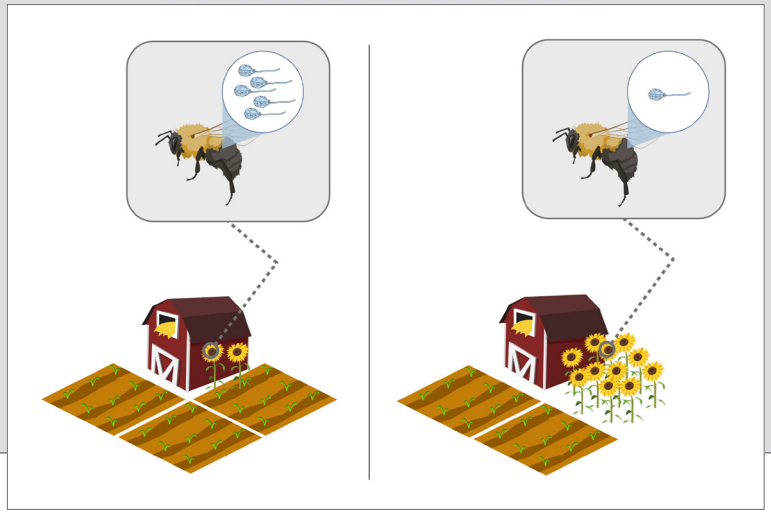


Figure 3. Bumble bees on farms with more sunflower had less Crithidia.

3. HOW BROAD IS THIS EFFECT?

Many different types of sunflower pollen reduced *Crithidia* in *B. impatiens*, including goldenrod, which is in the sunflower family but is not that closely related.

Researchers exposed bees to *Crithidia* and then fed them nine varieties of commercial sunflower, four varieties of wild sunflower and two species of goldenrod, a distant sunflower relative.

They found that all sunflower or goldenrod pollen reduced *Crithidia* 20-40-fold when compared to buckwheat pollen (and most reduced *Crithidia* compared to wildflower pollen). This is important because it implies that sunflower's medicinal qualities may extend to other members of the sunflower family, a diverse plant plant group found all over the world. Read the full paper here.

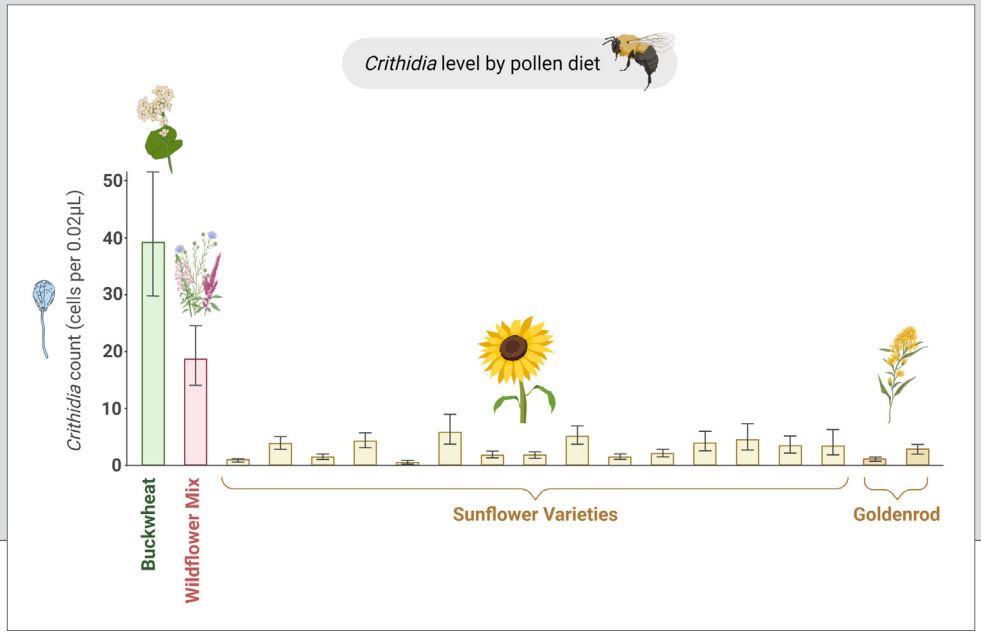


Figure 4. Pollen from multiple sunflower varieties and goldenrod species reduced Crithidia *levels relative to buckwheat pollen and a wildflower pollen mix. Adapted from LoCascio et al. 2019.*

Sunflower pollen reduced *Crithidia* in queens and workers, but not males.

Researchers tested whether sunflower affects bee castes differently. They found that it reduced *Crithidia* in females (queens and workers) but not males. The effect on queens is important because daughter queens that emerge in the fall establish new colonies the following spring. Males had relatively low *Crithidia* levels regardless of diet, which may be due to the fact that they consume very little pollen, and *Crithidia* is low when bees don't eat pollen. Read the full paper here.

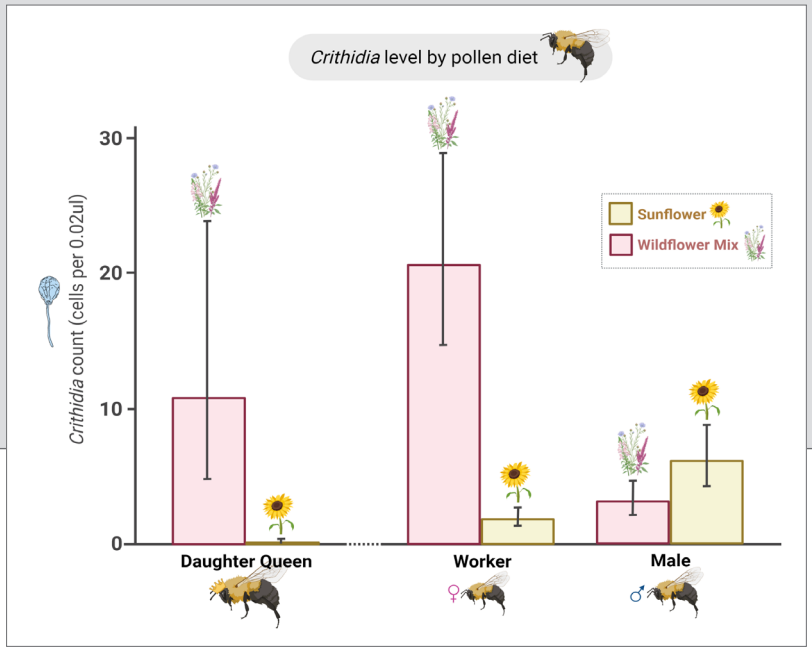


Figure 5. Sunflower pollen reduced Crithidia *infections in queens and workers but not male bumble bees. Adapted from Fowler et al. 2020.*

Sunflower pollen did not reduce *Crithidia* as dramatically in other bumble bee species.

Researchers tested whether sunflower pollen reduced *Crithidia* infections in three other wild bumble bee species: *Bombus griseocollis, Bombus bimaculatus*, and *Bombus vagans*. They found that it slightly reduced *Crithidia* infection in *B. bimaculatus* and *B. vagans* and did not reduce infection in *B. griseocollis*. *B. impatiens, B. bimaculatus* and *B. vagans* are more closely related to each other than they are to *B. griseocollis*. Read the full paper here.

Bombus Griseocollis, illustration by Steve Buchanan, courtesy of the Pollinator Partnership

A 50% sunflower pollen diet reduced *Crithidia* infections.

Dr. Adler's collaborator Becky Irwin and her team at NC State University tested whether sunflower pollen still reduced *Crithidia* when combined with wildflower pollen. This is important because sunflower pollen is low in protein, and bees cannot eat exclusively sunflower pollen for long periods of time. The team fed individual bees either 100% sunflower pollen, 50% sunflower pollen, 25% sunflower pollen, or 100% wildflower pollen. They found that even a 50% sunflower diet reduced *Crithidia* infections. Read the full paper here.

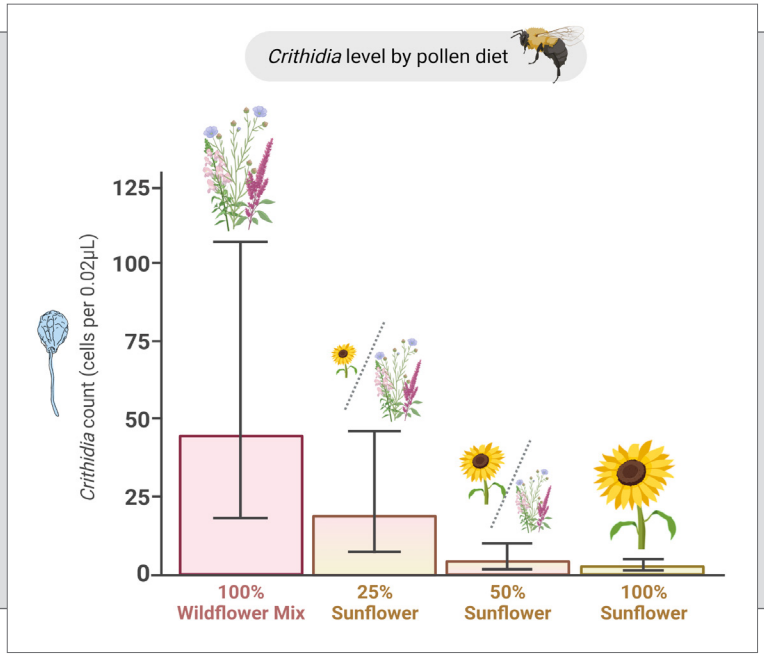


Figure 6. A 50/50 sunflower/wildflower pollen mix reduced Crithidia in commercial colonies relative to a 100% wildflower pollen mix. Adapted from Giacomini et al. 2021.

4. WHY DOES SUNFLOWER REDUCE *CRITHIDIA*?

Sunflower may reduce *Crithidia* because of its spiky outer shell.

Researchers in the lab isolated different chemical components of sunflower pollen (nine fatty acids and two defensive compounds) and fed them individually to bumble bees. They found that none of the compounds individually reduced *Crithidia*. Read the full paper here.

Then they separated the spiky shell from the other pollen components and fed it to bees. They found that the hollow spiky shell alone reduced *Crithidia* as much as whole sunflower pollen, pointing to a physical mechanism. This may explain why pollen from other plants in the sunflower family (which also have spiky pollen), reduce *Crithidia*. Figueroa et al., in prep.

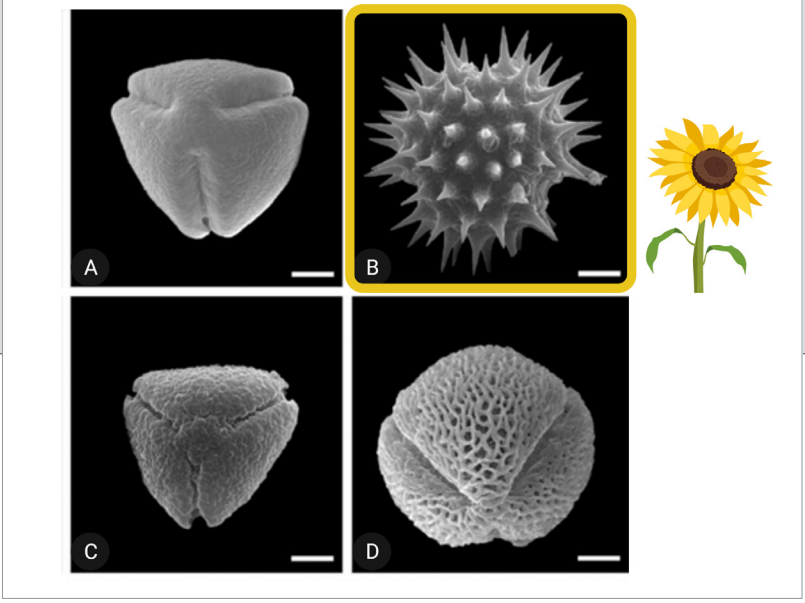


Figure 7. SEM photographs of some pollen types. Sunflower pollen is in the top right corner; notice how spiky it is. Pollen key: A. Sarcomphalus mistol. B. Helianthus annuus. C. Eugenia uniflora. D. Schinopsis balansae. Scale bars – 5 µm. Adapted from Salgado et al. 2017.

Next Steps

- The lab is exploring how commercially grown cut flowers in the sunflower family affect bumble bee health. This research could help us understand the impact of cut flower production on bees, and whether cut flowers could be a way to improve habitat for bees in agricultural areas.
- The lab is also assessing the value of pollen from different native plants, which could be used to create pollinator habitat in conservation areas.
- They are also collaborating with ecologists and molecular biologists to understand how pollen affects *Crithidia* at a molecular level, how plants affect disease transmission, and what plants ar visited most by bees, in order to model how plant communities affect bee health.

Acknowledgements

Fact sheet by Hannah Whitehead, UMass Extension. Edits by Lynn Adler and members of the Adler lab. Figures and graphics created using BioRender.com. Funded by USDA NIFA grant 2016-07962 and The University of Massachusetts Center for Agriculture, Food and the Environment. March 2022.

Works Cited

If you are are unable to access any Adler Lab papers, email Lynn Adler at lsadler@umass.edu

Adler Lab and collaborator papers on sunflower pollen

Adler, L. S., Fowler, A. E., Malfi, R. L., Anderson, P. R., Coppinger, L. M., Deneen, P. M., Lopez, S., Irwin, R. E., Farrell, I. W., & Stevenson, P. C. (2020). Assessing Chemical Mechanisms Underlying the Effects of Sunflower Pollen on a Gut Pathogen in Bumble Bees. *Journal of Chemical Ecology*, *46*(8), 649–658. https://doi.org/10.1007/s10886-020-01168-4

Fowler, A. E., Giacomini, J. J., Connon, S. J., Irwin, R. E., & Adler, L. S. (2022). Sunflower pollen reduces a gut pathogen in the model bee species, Bombus impatiens, but has weaker effects in three wild congeners. *Proceedings of the Royal Society B: Biological Sciences*, *289*(1968), 20211909. https://doi.org/10.1098/rspb.2021.1909

Fowler, A. E., Stone, E. C., Irwin, R. E., & Adler, L. S. (2020). Sunflower pollen reduces a gut pathogen in worker and queen but not male bumble bees. *Ecological Entomology*, *45*(6), 1318–1326. https://doi.org/10.1111/een.12915

Giacomini, J. J., Connon, S. J., Marulanda, D., Adler, L. S., & Irwin, R. E. (2021). The costs and benefits of sunflower pollen diet on bumble bee colony disease and health. *Ecosphere*, *12*(7), e03663. https://doi.org/10.1002/ecs2.3663

Giacomini, J. J., Leslie, J., Tarpy, D. R., Palmer-Young, E. C., Irwin, R. E., & Adler, L. S. (2018). Medicinal value of sunflower pollen against bee pathogens. *Scientific Reports*, *8*(1), 14394. https://doi.org/10.1038/s41598-018-32681-y

LoCascio, G. M., Aguirre, L., Irwin, R. E., & Adler, L. S. (2019a). Pollen from multiple sunflower cultivars and species reduces a common bumblebee gut pathogen. *Royal Society Open Science*, *6*(4), 190279. https://doi.org/10.1098/rsos.190279

Other referenced papers

Brunner, F. S., Schmid-Hempel, P., & Barribeau, S. M. (2014). Protein-poor diet reduces host-specific immune gene expression in Bombus terrestris. *Proceedings. Biological Sciences*, *281*(1786), 20140128. https://doi.org/10.1098/rspb.2014.0128

Gillespie, S. (2010). Factors affecting parasite prevalence among wild bumblebees. *Ecological Entomology*, *35*(6), 737–747. https://doi.org/10.1111/j.1365-2311.2010.01234.x

McAulay, M., & Forrest, J. (2019). How do sunflower pollen mixtures affect survival of queenless microcolonies of bumblebees (Bombus impatiens)? *Arthropod-Plant Interactions*, *13*. https://doi.org/10.1007/s11829-018-9664-3

Tasei, J.-N., & Aupinel, P. (2008). Nutritive value of 15 single pollens and pollen mixes tested on larvae produced by bumblebee workers (Bombus terrestris, Hymenoptera: Apidae). *Apidologie*, *39*(4), 397–409. https://doi.org/10.1051/apido:2008017