Study finds both habitat quality and biodiversity can impact bee health

December 5 2022

European honeybee on a redbud flower. Honeybees were among the four most consistently abundant types of bees found during the University of Michigan study. Lower levels of three common viral pathogens were strongly linked to greater species richness among local bee communities. Credit: Michelle Fearon

Efforts to promote the future health of both wild bees and managed

honeybee colonies need to consider specific habitat needs, such as the density of wildflowers.

At the same time, improving other habitat measures—such as the amount of natural habitat surrounding croplands—may increase bee diversity while having mixed effects on overall bee health.

Those are the key findings from a new analysis of several thousand Michigan bees from 60 species. The study looked at how the quality and quantity of bee habitat surrounding small farm fields affects the levels of common viral pathogens in bee communities.

"Future land management needs to consider that broadly improving habitat quality to benefit pollinator community diversity may not necessarily also benefit pollinator health," said University of Michigan biologist Michelle Fearon, lead author of a study published in the journal *Ecology*. The other authors are from U-M and the University of Washington.

"To promote pollinator health, we need to focus on improving specific habitat quality features that are linked to reducing pathogen prevalence, such as planting greater density of flowers," said Fearon, a postdoctoral fellow in the Department of Ecology and Evolutionary Biology.

Bees are indispensable pollinators, supporting both agricultural productivity and the diversity of flowering plants worldwide. But in recent decades, both native bees and managed honeybee colonies have seen population declines, which are blamed on multiple interacting factors including habitat loss, parasites and disease, and pesticide use.

As part of the work for her U-M doctoral dissertation, Fearon and her colleagues netted and trapped more than 4,900 bees at 14 winter squash farms in southeastern Michigan, where both honeybees and wild native

bees pollinate the squash flowers.

The bees were analyzed for the presence of three common viral pathogens. Consistently, lower virus levels were strongly linked to greater species richness, or biodiversity, among local bee communities. The number of bee species at each farm ranged from seven to 49.

Those findings, published in February 2021 in *Ecology*, provided support for what ecologists call the dilution effect. This controversial hypothesis posits that increased biodiversity can decrease, or dilute, infectious disease transmission.

But an unresolved question lingered after that study was published: Was biodiversity truly responsible for the observed reductions in viral levels, or was there something about habitat quality that drove changes in both bee biodiversity and viral pathogen prevalence?

"Many studies have shown that high-biodiversity communities are ones with low rates of infectious disease. But we also know that better habitat quality often leads to greater biodiversity," said study co-author Chelsea Wood of the University of Washington, a former Michigan Fellow at U-M.

"So which factor is actually driving down disease risk: biodiversity or habitat? Do high-biodiversity communities dilute disease prevalence? Or do communities in high-quality habitat have healthier hosts, who are better at resisting infection? Our data show that some apparent 'dilution effects' could actually have nothing at all to do with biodiversity."

The University of Michigan biodiversity study was conducted at 14 winter squash farms across the state. European honeybees and wild native bees help pollinate the squash flowers. A diverse array of native bees were found in the fields and along the field edges. Credit: Michelle Fearon

Previous studies have demonstrated that habitat factors can directly influence both an animal's nutritional status and the strength of its immune system, which in turn can influence its susceptibility to pathogens. For example, Eurasian red squirrels living in fragmented habitats host greater gastrointestinal parasite burdens than those living in continuous forest habitats.

To get to the root cause of their Michigan bee observations, Fearon and her co-authors generated models allowing them to rigorously disentangle the effects of habitat characteristics on patterns of pathogen prevalence.

They reexamined the previously collected bee data and added new information about local and landscape-level habitat. For the study, the researchers defined high-quality bee habitat as areas that provide sufficient quantity and diversity of floral resources (both pollen and nectar) to sustain good pollinator nutrition.

At the local level, floral richness (meaning flower species diversity) and floral density were the key indicators of high-quality habitat. At the landscape level, proportion of "natural areas" surrounding farm fields and landscape richness (meaning areas with more land cover types) were the key characteristics. Natural areas included deciduous, evergreen and mixed forest; herbaceous and woody wetland; shrubland; grass pasture; and wildflower meadow.

The researchers found that habitat can have both positive and negative impacts on pathogen levels in bee communities. This is evidence for what the authors called a habitat-disease relationship, where habitat quality has a direct impact on bee health.

In general, a higher proportion of natural area and a greater richness of land cover types were associated with increased viral prevalence, while greater floral density was associated with reduced viral prevalence.

"Areas with greater floral abundance could provide better pollen and nectar resources for bees to help them resist or fight off infection," said study co-author Elizabeth Tibbetts, a professor in the U-M Department of Ecology and Evolutionary Biology who was Fearon's dissertation adviser. "Additionally, greater floral abundance may reduce the effective foraging density of pollinators and result in reduced pathogen transmission."

More natural area was also associated with higher bee species diversity, which in turn contributed to reduced, or diluted, viral prevalence.

"Most importantly, we found that greater habitat quality in the surrounding landscape was a key driver of the dilution effect that we previously observed," Fearon said. "This provides evidence for a habitat-driven biodiversity-disease relationship, where habitat quality indirectly impacts bee health by altering bee species diversity.

"But different habitat-quality metrics impacted patterns of viral prevalence both positively and negatively. This means that habitat quality has the potential to decrease or increase viral prevalence in pollinators depending on the relative strengths of the habitat-disease and biodiversity-disease pathways.

"So, it is important to consider how improving specific habitat quality measures may impact bee diversity and bee health in different ways."

More information: Michelle L. Fearon et al, Habitat quality influences pollinator pathogen prevalence through both habitat–disease and biodiversity–disease pathways, *Ecology* (2022). DOI: 10.1002/ecy.3933

Provided by University of Michigan