ENVIRONMENTAL SCIENCE JOURNAL FOR TEENS

MARCH 2018

How do pesticides get into honey?

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Abstract

Honey is nature's sweetest gift. But did you know that honey may contain *pesticides?* Farmers use pesticides to kill *pests* that harm their *crops*. But pesticides also hurt honey bees and other beneficial insects. Furthermore, when bees collect *nectar* from flowers which received pesticide treatments, these chemicals make their way into the honey. In the past, scientists found *neonicotinoids* (a class of pesticides) in about half of the honey samples collected in the United Kingdom.

Since 2014, the European Union banned neonicotinoids in flowering crops that bees visit. We wanted to know how effective this policy was. Does UK honey still contain neonicotinoids? Here, we collected and tested honey samples from beekeepers across the UK. We found that about a fifth of all honey contained neonicotinoids. These chemicals are not at dangerous levels for human health but may harm the bees in the long run.

Introduction

Thanks to hard working honey bees, we have this delicious and beneficial food called honey (Fig. 1). However, making honey is not honey bees' most important job. As they collect *nectar* (the sugary liquid from flowers), they also transfer *pollen* (cells needed to make seeds) between plants (Fig. 2). We call this *pollination*. Many crops like apples, berries, and almonds depend on bees for this service. And so do we if we want to eat them!

Unfortunately, bee populations are declining worldwide. Many things are likely causing this, including habitat loss and climate change. However, scientists also think that pesticides (chemicals sprayed on fields to kill insects) are partly to blame.

Figure 1:
Honey bees storing honey in their hive. They make it to keep their colony going during the winter when nectar and pollen are scarce.

Figure 2:
A honey bee collecting nectar and pollen from a flower. The bees attach the pollen to the hairs of their hind legs - can you see the big orange pollen "baskets"? A bee can carry her own weight in pollen on her legs! While she is collecting pollen for her own use, the bee often gets covered in pollen, which then helps pollinate the flowers the bee visit next. (Photo credit: Andreas Tepte)

One type of pesticide especially harmful to bees are so-called *neonicotinoids*. An important thing to remember is that these pesticides do not kill the bees outright. Instead, neonicotinoids mess with bees' brains - affecting their ability to learn and remember. That may be a death sentence for bees because they need to know how to return to their hives. The fewer bees return to hives, the less likely the hives are to survive.

But how do bees get these chemicals? Neonicotinoids are usually applied to seeds and are known as *systemic pesticides*. This means the plant absorbs them into all its parts, even into the nectar and pollen that bees collect and make into honey. By drinking the nectar and eating some of the pollen, and feeding some of the honey to their babies (scientists call these larvae), the bees take in the pesticides.

In 2014, not surprisingly, neonicotinoids showed up in about half of the honey produced in the UK. Alarmed by the risk to bees, the European Union banned three types of neonicotinoids on mass flowering crops that bees visit, including oilseed rape and sunflower.

We wanted to check the effectiveness of this policy. We expected some neonicotinoids that were applied before the ban to remain in the soil and show up in honey samples. Let's see if this was the case!

Methods

We suspected that the level of neonicotinoids in honey samples would depend on the previous applications of the pesticide in the area surrounding the hive. To test our *hypothesis*, we analyzed the honey samples from before and after the ban.

Honey samples: We collected 130 samples from individual amateur beekeepers across the UK (Fig. 3): 21 samples from before the ban (2014), and 109 samples from after the ban (2015).

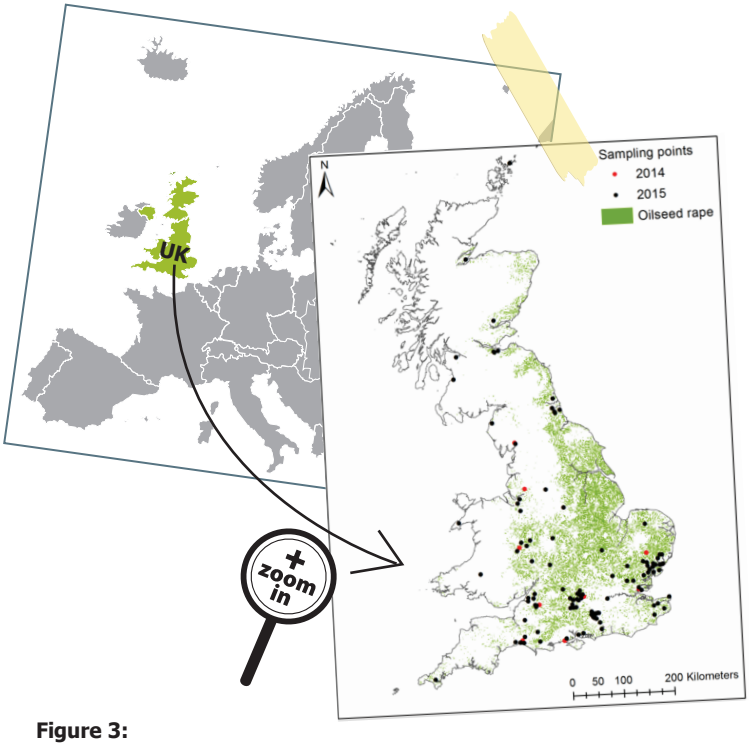


Figure 3:
The location of our honey collection sites and nearby oilseed rape fields (green areas) in the UK. We predicted that the pesticide levels in honey would depend on the previous application of pesticides in areas surrounding the beehives.

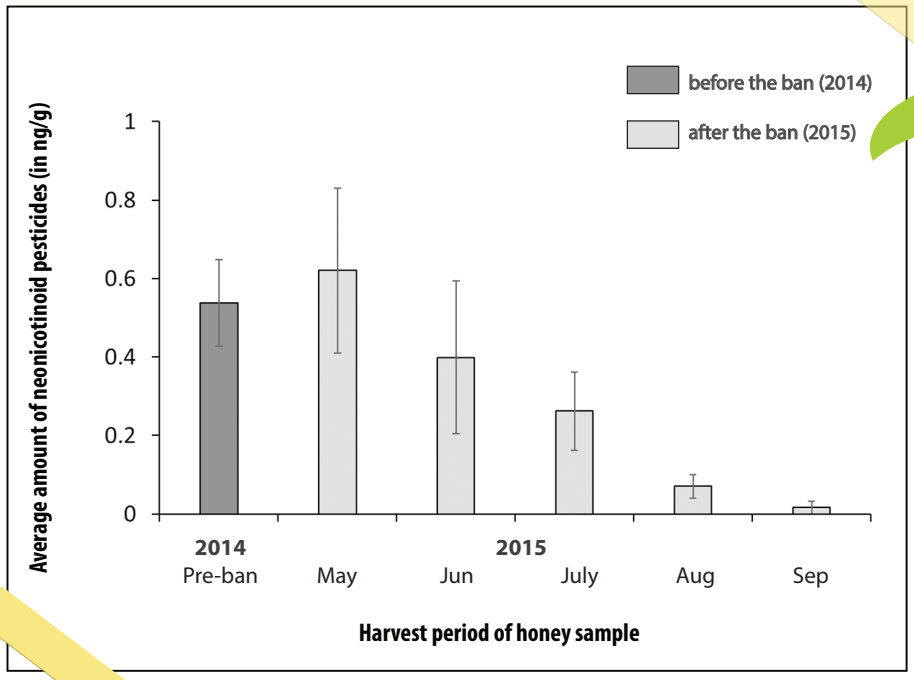
Honey analysis: We took a small amount (1.5 ml) from each sample and froze it at really cold temperatures (-80℃). Then, we separated it into its individual components and looked for three types of neonicotinoids: clothianidin, thiamethoxam, and imidacloprid.

Bees' exposure to pesticides: Oilseed rape (Fig. 4) is the main mass flowering crop in the UK. It relies on honey bees and other insects for pollination. Farmers treated oilseed rape with neonicotinoid before it was banned. These large oilseed rape fields have attractive flowers where bees most likely picked up neonicotinoids. But where do the bees pick up this chemical after the ban? One potential risk is that when oilseed rape is grown on soils where neonicotinoids have been used in the past, they may pick up old neonicotinoids that have remained in the soil. Using a crop map of the UK, we calculated the amount of oilseed rape within a 2 km radius around each hive (this is how far honey bees usually forage). Then, we analyzed the relationship between the total neonicotinoid amount in the honey samples and oilseed rape surrounding the hive.

Figure 4:
Bees come in contact with pesticides while they collect nectar and pollen from oilseed rape flowers, which are planted on large fields like this one. Rapeseed is the third-largest source of vegetable oil in the world.

Results

- Before the ban, about half of all honey samples contained neonicotinoids. After the ban, one fifth of them contained these pesticides.
- Honey collected before the neonicotinoids were banned had about twice as much neonicotinoid pesticides as honey collected after the ban.
- After the ban (in 2015), we found more pesticides in the samples early in the season (in May-June 2015) than later in the year (Fig. 5).
- Among the three types of pesticides, clothianidin was more common than thiamethoxam and imidacloprid.



May-June 2015 samples had the highest average amounts of pesticides. June has about 0.62 nanograms of residue per gram of honey. (1 Nanogram is 1/1000000000th (one billionth) of a gram.) What is the trend in this bar graph from May to September of 2015? Why?

Remember that the flowering crops did not receive pesticides during that period. How could the bees still pick up the pesticides?

Figure 5:
Average amounts of neonicotinoid pesticides in honey. The vertical lines are error bars which tell us how far the average of each sample spread out from the average of the group.

Discussion

So we still found neonicotinoids in honey even after they were banned. Interestingly, we found the biggest amount of these pesticides in honey that was harvested early in the year (May-June 2015) after the ban. This is also the time of year when oilseed rape flowers. The more oilseed rape surrounding the hive, the more neonicotinoids showed up in the honey. This indicates that oilseed rape crops may contain amounts of neonicotinoids. But where do they get them from, even though they're banned? From the soil!

When seeds are treated with pesticides and then planted into soil, these toxic chemicals leach into the soil and contaminate it for future plants. And because of the systemic nature of the pesticides, neonicotinoids move into all parts of the plants including pollen and nectar, where they can harm bees.

To summarize: neonicotinoids remain in farm soil and keep showing up in UK honey even after their ban. The good news is: levels are low and don't pose a risk to human health. But for bees, it's a different story: being exposed to neonicotinoids (even at low levels) for a long time is a threat for honey bees and other insect pollinators. If bees disappear, we may lose the plants they pollinate and all their wonderful food products. This could threaten global *food security* which means we won't have enough food to feed everybody.

Conclusion

We are losing bees at an alarming rate. Habitat loss, toxic pesticides, diseases, and parasites are possible reasons. But you can help to save bees! Here are some bee friendly ideas:

- Plant native plants, flowers and herbs in your backyard, school, or even on your balcony.
- Set out a shallow dish of water with some pebbles for bees. (Bees get thirsty, too!)
- Support bee-friendly farming. Shop from local, organic farms, and local beekeepers.
- Learn more about bees and the challenges they are facing. Spread the word!
- Participate in citizen science projects to support scientific research about bees.

Glossary of Key Terms

Crop – a cultivated plant that is grown for human consumption (food, fiber).

Food security – to have reliable access to enough affordable and nutritious food to keep people healthy.

Hypothesis – a prediction scientists make (usually based on observation or previous scientific knowledge) which can be tested.

Nectar – a sugary liquid in flowers plants to encourage pollination by insects and other animals. It is collected by bees to make into honey.

Neonicotinoids – a systemic agricultural insecticide (pesticide that kills insects) resembling nicotine.

Pest – a destructive insect or other animal that attacks crops, food, livestock. For instance, mice are pests for cereal crops.

Pesticides – a substance used for destroying insects or other organisms harmful to cultivated plants or to animals.

Pollen – a fine powdery substance, which varies in colour (depending on the plant), discharged from the male part of a flower to fertilize the female part of the flower and make seeds.

Pollination – the process where insects, birds, bats and the wind move pollen from one flowering plant to another in order to make seeds and reproduce.

Pollinator – an animal or insect (birds, bats, butterflies etc.) that pollinate flowers. Bees are important pollinators for a majority of food crops.

Systemic pesticides – chemicals that are actually absorbed by a plant when applied to seeds, soil, or leaves. The chemicals then circulate through the plant's tissues, killing the insects that feed on them. Unlike with traditional insecticides, you can't wash or peel off systemic pesticide residues.

REFERENCES

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National library of health: Pesticides
https://kidsenvirohealth.nlm.nih.gov/subtopic/002/chemicals/022/pesticides/

Buzz about bees: Wonderful world of bees
https://www.buzzaboutbees.net/about-bees.html

Check your understanding

1. Bees are really awesome. Why are they so important for us and the world?

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2. The pesticides called neonicotinoids are a threat to bee populations. How do bees get these pesticides?

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3. Scientists found that honey still contains neonicotinoids despite their ban in the European Union. How is that possible?

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4. What are the negative effects of neonicotinoids on honey bees?

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5. Bees and other insect pollinators are very important for the global food chain but their populations are declining fast. What are some of the reasons? And how could we help?
