



Notes

from the Lab:

The Latest Bee Science Distilled

by Scott McArt

Pesticides are currently harming bees across Europe

In last month's column I described how the current pesticide risk assessment process for pollinators is inadequate in the United States, Europe, and other areas. I used the word "inadequate" because we know that pesticides are currently contributing to annual honey bee colony losses and declines of wild pollinators.

In this month's column I'm going to highlight a paper that connects the dots between the inadequate pesticide risk assessment process overseen by the European Food Safety Authority (EFSA) and negative impacts on bumble bees across Europe.

Since ABJ is an American magazine and most readers live in America,

it's worth noting that the EFSA has a more pollinator-friendly pesticide risk assessment process than its equivalent in the USA, which is overseen by the Environmental Protection Agency (EPA). So, if you're an American reading this article and wondering what the results of a similar study conducted in the USA might reveal, please keep in mind that as of 2016 there were 72 pesticides approved for outdoor agricultural use in the USA that were banned or in the process of being banned in the European Union (EU) due to unacceptable risk to humans and wildlife. Of the 1.2 billion pounds of pesticides used in USA agriculture in 2016, roughly 27% were of

pesticides banned in the EU (Donley, 2019). That includes neonicotinoid insecticides, which were banned from use on pollinator-attractive outdoor crops in the EU in 2013, then fully banned from all outdoor agricultural use in 2018. Neonicotinoid insecticides are currently the most-used insecticides in the USA.

OK, let's get to it. Are bumble bees in Europe exposed to pesticides in agricultural landscapes? Are high-risk exposures linked to reduced colony performance? Is it likely that pesticide use is having negative consequences on bee populations in Europe? In other words, how well does the current pesticide risk assessment process

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Photos 1 & 2 Sentinel buff-tailed bumble bee colonies (left) were placed at 106 sites across eight European countries to assess how pesticide exposure was related to colony productivity. Sites were located adjacent to an oilseed rape field or an apple orchard and the pollen gathered by foraging bees (right) was collected for pesticide residue analyses in the lab.



Photos 3 & 4 Buff-tailed bumble bee colony performance was tracked by weighing the colonies before and after focal crop bloom (left) and by counting all bees and brood (right) at the termination of bloom.

protect pollinators in Europe? These are the topics for the seventy-second *Notes from the Lab*, where I summarize “*Pesticide use negatively affects bumble bees across European landscapes*,” written by Charlie Nicholson & Jessica Knapp and colleagues and published in the journal *Nature* [2023].

The paper by Nicholson & Knapp and colleagues summarizes one study from a broader project called PoshBee (see: <https://poshbee.eu/>). PoshBee brought together 42 partners across Europe, including seven beekeeping associations, eight farming organizations, four companies, and 23 academic/government research organizations. A very impressive group to tackle the issue of pesticide risk to pollinators!

While the scope of PoshBee was ambitious and had an impact well beyond the individual study summarized here, even this study was impressively ambitious. In total, the authors monitored 316 buff-tailed bumble bee colonies at 106 sites across eight European countries (see Photos 1 & 2 and Figure 1, panel a).

At each site, which was located adjacent to an oilseed rape field or an apple orchard, bumble bee colony performance was tracked by weighing the colonies before, during, and after focal crop bloom (see Photo 3) and by counting all bees and brood at the termination of bloom (see Photo 4). These colony performance metrics were assessed for their relationship to pesticide residues in the pollen collected by the bees. Specifically, at the termination of bloom at each site, colonies were harvested and the stored pollen (analogous to bee bread in honey bee colonies) was collected

and pooled for each site, sent to the lab, and screened for residues of 267 pesticides. A subsample of the pollen was also analyzed for palynological identity to understand which plants the pollen came from.

So, what did they find? Were the bees exposed to pesticides? Yes, the pollen collected by bees contained eight pesticides, on average. Most pollen samples contained at least one pesticide and the most-contaminated sample contained 27 pesticides.

For readers in the USA who are wondering if eight pesticides per pollen sample is a lot, here’s some context. Pollen collected by honey bees during commercial apple pollination in New York contained 17 pesticides, on average (McArt et al., 2017) and pollen collected by bumble bees and honey bees during blueberry pollination in Michigan contained an average of 18 and 35 pesticides, respectively (Graham et al., 2021). So, compared to pesticide exposure during crop pollination in the USA, the average of eight pesticides per pollen sample from this European study is actually quite low.

Were there any high-risk exposures? Yes. While the majority of pesticide residues were fungicides, which are relatively non-toxic to bees, there were eight insecticides detected, sometimes at troubling levels. The oxadiazine insecticide indoxacarb was found in 16% of pollen samples at a mean concentration of 1,310 parts per billion (ppb) and a maximum of 3,380 ppb. To put that in perspective, the LD₅₀ of indoxacarb for an average-weight honey bee worker is 1,550 ppb.

Indoxacarb was the most-risky pesticide detected, but two other in-

secticides contributed substantially to risk — the organophosphate chlorpyrifos and the spinosyn insecticide spinosad. Interestingly, 8% of pollen samples also contained the EU-banned neonicotinoid insecticide imidacloprid, highlighting either exposure from non-agricultural uses, contamination from greenhouses (e.g., Herbertsson et al., 2021), environmental persistence in agricultural areas, illegal agricultural use, or exposure from “emergency authorizations” which have been granted in several EU countries (e.g., EFSA, 2021).

Was pesticide risk related to reduced colony performance? Yes. As can be seen in Figure 1, panel b, there was a negative relationship between pesticide risk (i.e., toxicity-weighted pesticide concentrations in each pollen sample) and productivity of colonies. A nearly identical negative relationship can be seen between pesticide risk and colony weight gain (see Figure 1, panel d). In panel c, we see that these negative relationships occurred in apple but not oilseed rape. If you squint, you can also see that the yellow points in panel c are further to the left than the green points; this means there were fewer harmful pesticide exposures during oilseed rape pollination compared to apple pollination, which may partially explain the stronger trends in apple.

Well, this is troubling. Do the results from this study mean that pesticides are currently having a negative impact on wild bee populations in Europe? Very likely. As with anything in science, it’s impossible to prove that something is true. That’s just not how

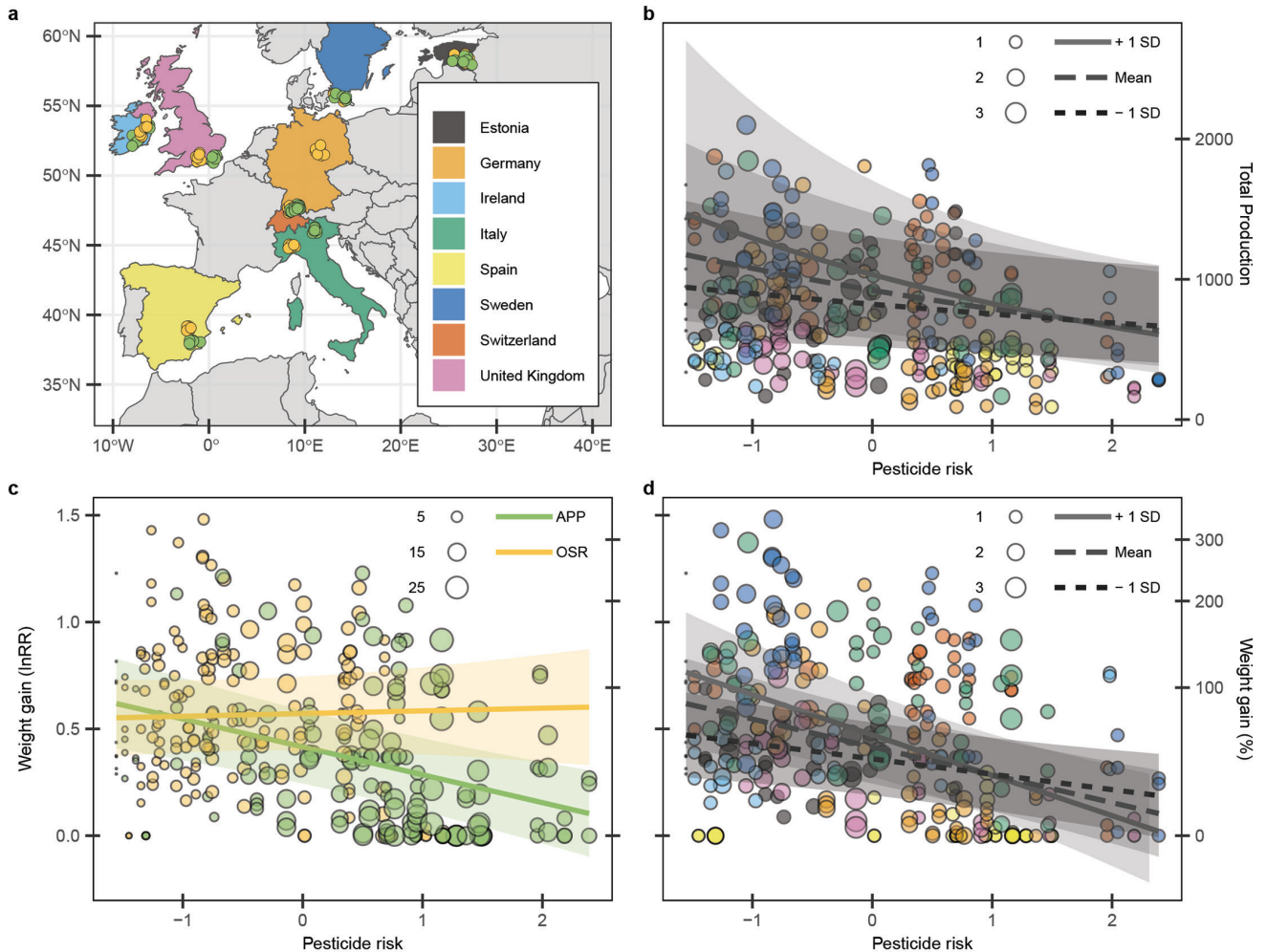


Figure 1 (a) Buff-tailed bumble bee (*B. terrestris* L.) colonies ($n = 316$) were deployed adjacent to apple (APP, green points) and oilseed rape (OSR, yellow points) across eight European countries. (b) Colony production (total number of produced bees estimated by the sum of closed and eclosed cocoons) declined with pesticide risk (log-transformed and centered toxicity-weighted pesticide concentrations) in pollen stores. (c,d) Colony weight gain and percentage change also declined with pesticide risk (note double and shared y axes). Focal crop and landscape context modified these effects, with declines at apple (c; green line) though not at oilseed rape sites (c; yellow line) and in landscapes with more cropland (b,d; solid line +1s.d. proportion of cropland). Point colors in b and d correspond to country colors in a and are scaled in size by the factor by which the mixture of compounds in a sample is riskier than the single most risky compound. Points in c are scaled by the number of pesticide compounds quantified in a sample. Shaded areas around the best-fit lines represent the regression 95% CI.

science works. But there are at least three reasons why the results from this study paint an ominous picture for wild bee populations.

First, bumble bee colony weight gain is tightly linked with fitness, including the production of new queens and males. So, the negative relationship between pesticide risk and weight gain means that pesticides are likely having an impact on bumble bee reproduction, which is a key factor that shapes population change.

Second, the authors actually measured new queen production in the sentinel colonies, which declined with increasing pesticide risk. This means it's not just strong inference that implies population change, the data directly suggest this is true.

Third, bumble bees are social and, like social honey bees, possess life-history and social detoxification strategies known to buffer the impact of pesticides. These strategies do not exist for solitary bees, which comprise the vast majority of the ~20,000 species of bees on earth and also happen to be highly important crop pollinators. This means the implications of the authors' results for solitary bees are likely even more concerning than for social bees like bumble bees and honey bees.

What's the take-home message?

Well, a key take-home from last month's column was that post-approval monitoring of pesticide impacts on pollinators is not currently part of the risk assessment process

overseen by the EFSA, EPA, or other regulatory agencies. The study highlighted here is a post-approval monitoring study, conducted by independent researchers because neither regulatory agencies or the producers of pesticides (i.e., the pesticide industry) conduct such studies. And it shows very clearly that pollinators are currently being harmed by pesticide exposure in the real world.

Folks, that's the take-home. In other words, here is very strong evidence that the regulatory process overseen by the EFSA is not sufficiently protective in limiting the collateral environmental damage of agricultural pesticide use. Now, the question is, will anything be done to better protect pollinators in the future?

Until next time, bee well and do good work.
Scott McArt

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