Notes from the Lab:

The Latest Bee Science Distilled

by Scott McArt

Are all bees created equal when it comes to pesticide risk?

Last fall, I took my two dogs for a walk in the woods behind my house. The black Labrador mix came home with 56 ticks (my daughters meticulously counted as we pulled them off of her!). The Boston terrier came home with only one tick.

I could have predicted my Lab would bring home more ticks. She engaged in several high-risk tick acquisition behaviors such as sprinting through thickets of bushes the entire time we were outside. Conversely, the Boston terrier stayed by my side and actually begged to be held on several occasions. And then there's the Lab's high-risk tick acquisition fur. The slight non-Lab portion of her genes has resulted in fur so thick it's essentially a dense forest of tick hiding places! Conversely, the Boston terrier's fur is so sleek that I think most ticks simply slide off.

What does this have to do with bees? Well, my black Lab and Boston terrier clearly experience different risk of acquiring ticks, perhaps in a similar way that different species of bees experience different risk from pesticides in agricultural landscapes. But is that true? Do attributes of bees such as sociality and foraging radius dictate which pesticides they're exposed to and the magnitude of risk they experience? Does the proportion of agricultural land surrounding their colonies/nests shape patterns of risk? These are the topics for the sixty-fourth *Notes from the Lab*, where I summarize ***"Ecological traits interact with landscape context to determine bees' pesticide risk,"*** written by Jessica Knapp and colleagues and published in the journal ***Nature Ecology & Evolution*** **[2023].**

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Photos 1 & 2 *Sentinel colonies/nests of the western honey bee (*Apis mellifera*), buff-tailed bumble bee (*Bombus terrestris*), and the red mason bee (*Osmia bicornis*) were placed in one of the eight apple orchards assessed in the study.*

For their study, Knapp and colleagues introduced bees of three different species to three pollination-dependent crops during bloom (see Figure 1, Photos 1 & 2). Their three bee species were the western honey bee (*Apis mellifera*), a social bee with an extensive foraging radius; the buff-tailed bumble bee (*Bombus terrestris*), a social bee with an intermediate foraging radius; and the red mason bee (*Osmia bicornis*), a solitary bee with a limited foraging radius. The three pollination-dependent crops where the bees were placed were oilseed rape, apple, and red clover.

Colonies/nests of each species were placed in eight different oilseed rape fields in May, eight different apple orchards in May/June, or eight different red clover fields in July/August (see Figure 1b-d). The researchers collected the pollen that each species brought back to their colonies/nests via pollen traps (honey bees; Photo 3), stealing the pollen from their provisions (mason bees; Photo 4), or manually removing the pollen from their bodies (Photo 5).

All pollen and nectar samples were brought to the lab and screened for the 120 pesticides included in the Swedish national monitoring scheme via liquid and gas chromatography coupled with mass spectrometry. To assess risk from the pesticide-con-

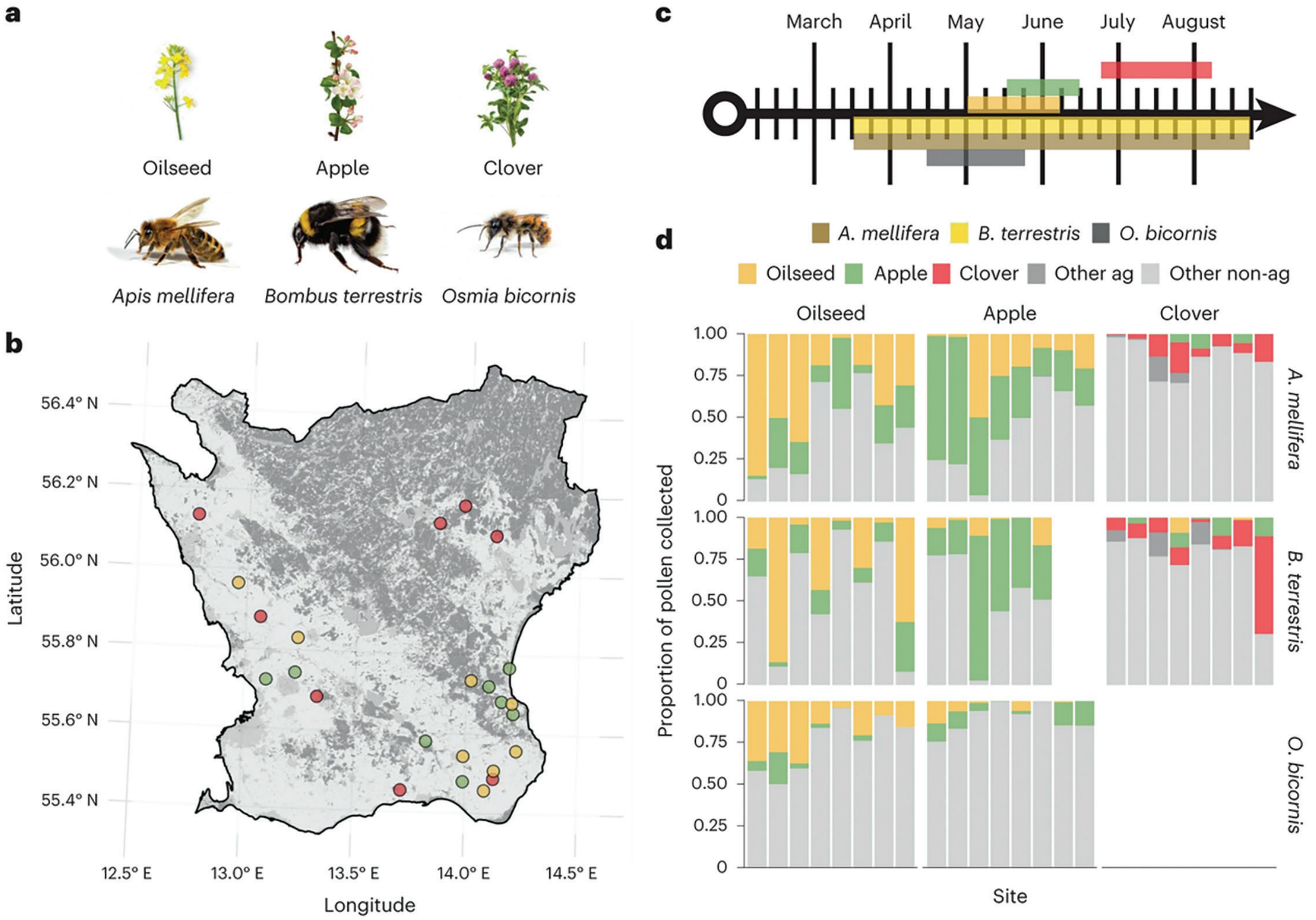

Fig. 1 *a,b, Sentinel colonies/nests of three bee species that vary in their sociality and foraging range to fields of three pollinator-dependent crops (a) were introduced across a gradient of land use in southernmost Sweden (b). The focal bee species were the western honey bee (*Apis mellifera*), a social extensive forager; the buff-tailed bumble bee (*Bombus terrestris*), a social intermediate forager; and the red mason bee (*Osmia bicornis*), a solitary limited forager. c, The activity periods and flowering phenology of bees and crops overlapped, except for red clover and* O. bicornis*. d, Non-agricultural (other non-ag) plant species/groups often dominated pollen use at each site (x axis) and bees tended to use more of the focal crop pollen than other agricultural (other ag) types. Pollen use and pesticide residue data are unavailable for red clover and O.* bicornis *due to non-overlapping phenologies (c). Due to colony failure, data are also absent for* B. terrestris *colonies at two apple sites.*

taminated pollen, toxicity data (i.e., the lethal dose for 50% of honey bees in 48-hr tests) was obtained from the literature for each individual pesticide. Risk was estimated as the sum of each pesticide residue divided by its toxicity. This is a common approach used by researchers and regulatory agencies to assess pesticide risk to bees from contaminated pollen.

All pollen samples were identified and categorized as crop vs. non-crop in origin. Crop pollen included a Brassicacae group (including oilseed rape; *Brassica napus*), *Malus* group (including apple; *Malus domestica*) and *Trifolium pratense* group (red clover; *T. pratense*) as shown in Figure 1d. Finally, the authors assessed landscape composition of each site within the flight radius of bees (1,000-2,000 m). They classified land into two categories: agricultural land (all types of agricultural use, such as annual crops, orchards, and seminatural grasslands) and non-agricultural land (including forest, urban areas, and water bodies).

So, what did they find? Were bees exposed to pesticides? Yes. Across all bee species and crops, 53 different pesticides were detected. More pesticides were detected in pollen from oilseed rape sites than apple and clover sites. Herbicides and fungicides comprised 80% of detections, but insecticides accounted for 99% of risk due to their greater toxicity to bees (bees are insects, after all!).

Did pesticide risk vary among bee species or crops? Surprisingly, there was no difference in the magnitude of pesticide risk among bee species. But there were differences in the types of pesticides contributing to risk among bee species. Four insecticides contributed to the majority of risk experienced by bees: an oxadiazine (indoxacarb) and three neonicotinoids (imidacloprid, acetamiprid, and thiacloprid). All three bee species were exposed to two of the riskiest compounds, indoxacarb and acetamiprid, while only honey bees were exposed to thiacloprid and only red mason bees were exposed to imidacloprid.

There was also a difference in pesticide risk among crops. Contaminated pollen collected at apple sites harbored greater risk compared to clover sites while risk at oilseed rape sites was intermediate.

Did landscape context shape patterns of risk? Yes, but only for buff-tailed bumble bees and red mason bees. Pesticide risk increased with the proportion of agricultural land for both of these species that have limited or intermediate foraging radii, while risk to honey bees (the bee with the largest foraging radius and most advanced communication system) was


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(L) Photo 3 *Pollen was collected from western honey bees (*Apis mellifera*) via a pollen trap.* **(R) Photo 4** *Pollen provisions were taken from red mason bees (*Osmia bicornis*) by opening recently finished nests.*

independent of the proportion of agriculture in the landscape.

Interesting. So what does all of this mean? Risk assessors want to know whether the species they use to assess risk provides representative results for other species that aren't used to assess risk. For bees, the western honey bee (*A. mellifera*) is often used as the model species for assessing risk. Because the authors found the magnitude of risk did not vary among bee species, this supports the notion that the western honey bee is a good model species for risk assessment, at least for individual bees (i.e., not full colonies). At the same time, the composition of high-risk pesticides varied among bee species. In other words, looking under the hood at what was creating risk revealed differences, indicating that individual honey bees are not a perfect representative species for assessing risk.

A newer topic of interest to risk assessors is understanding how risk is shaped by landscape context. The study by Knapp and colleagues shows very clearly that greater agricultural area in the landscape increases pesticide risk, but only for limited and intermediate foragers (mason bees and bumble bees in their study). This indicates that greater amounts of natural habitat and floral resources in landscapes can buffer against pesticide risk. Risk to honey bees was not modified by landscape context in this study, but I wouldn't go so far as to say honey bees don't care about natural habitat and uncontaminated floral resources. Clearly they do, as has been shown in other studies. Perhaps we just need to start thinking more like a honey bee (i.e., at a large scale and with large patches of flowers) when we design future wildflower plantings and natural habitat refuges.

Until next time, bee well and do good work.

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REFERENCE:

Knapp, J. L., C. C. Nicholson, O. Jonsson, J. R. de Miranda and M. Rundlöf. 2023. Ecological traits interact with landscape context to determine bees' pesticide risk. *Nature Ecology & Evolution*. **https://doi.org/10.1038/s41559-023-01990-5**


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Photo 5 *Pollen was manually removed from buff-tailed bumble bees (*Bombus terrestris*) with forceps.*

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