Notes from the Lab: The Latest Bee Science Distilled

by Scott McArt

A roadmap for how to minimize pesticide risk to bees

Every three years, many of the main players who are working to understand and improve pollinator health get together at the International Conference on Pollinator Biology Health and Policy (also called the "International Pollinator Conference"). This year's conference is from July 17-20 at the UC Davis Honey and Pollination Center (**https://honey.ucdavis.edu/pollinatorconference2019**) and the theme is "*Multidimensional Solutions to Current and Future Threats to Pollinator Health*."

If anything is clear regarding pollinator health, it's that no silver bullet exists to cure the current problem. Indeed, multidimensional solutions are necessary, not just advisable. Thus, on the eve of the 2019 International Pollinator Conference, it's timely that several leading researchers in the field of pesticide-pollinator interactions published a synthesis on the topic. The paper, ***"Pesticides and pollinators: A sociological synthesis,"*** written by Doug Sponsler and colleagues and published in the journal ***Science of the Total Environment* [662:1012-1027 (2019)]**, gives a roadmap for how biologists, social scientists, regulatory agencies and stakeholders must work together to minimize risk to bees. In other words, their paper outlines a multidimensional solution on the topic of pesticide risk to bees.

Sponsler and colleagues' synthesis was motivated by three key observations. First, despite a recent uptick in research on pesticide-pollinator interactions, scientists have a relatively poor understanding of the patterns and processes that govern exposure of pollinators to pesticides. Specifically, when growers, homeowners, or other pesticide applicators use a pesticide, we often don't know whether that pesticide will end up being encountered by bees, and in what quantity.

Second, while there's a wealth of knowledge on the toxicity of most pesticides to individual bees (especially the honey bee, *Apis mellifera*), we know relatively little about how toxicity to individual bees is linked to colony- or population-level outcomes. In other words, estimates of pesticide risk to bees are often occurring at the individual bee level, not at the colony level for social bees, or the population level for solitary and social bees.

Finally, links between pesticide risk (typically determined by scientists), pollination services and apicultural productivity (typically determined by growers and beekeepers) and biodiversity conservation (explicit goals of government regulatory agencies) are rarely made. It's these missing linkages that need to occur more often if pesticide risk to pollinators is to improve.

So, where should we be focusing efforts to make the links stronger? To start getting at this important question, Sponsler and colleagues created a conceptual framework for the pollinator-pesticide system based on three interlocking domains (Fig. 1). Domain 1 focuses on the human and ecological drivers governing pesticide use. In other words, what are the motivations for using pesticides? While pest pressure (or perceived pest pressure) is of course important, the decision of when and how to use a pesticide is largely governed by socioeconomic factors, such as pesticide availability and cost, values of the applicator, and availability of information. Thus, right off the bat it's clear that economics and human behavior drive the potential for bees to be exposed to pesticides.

The outcome of Domain 1 (i.e., how pesticides are used in space and time) comprise the inputs to Domain 2, where a pesticide's fate in the environment interacts with pollinator behavior and life-history to determine exposure. In this Domain we figure out when and where a pollinator

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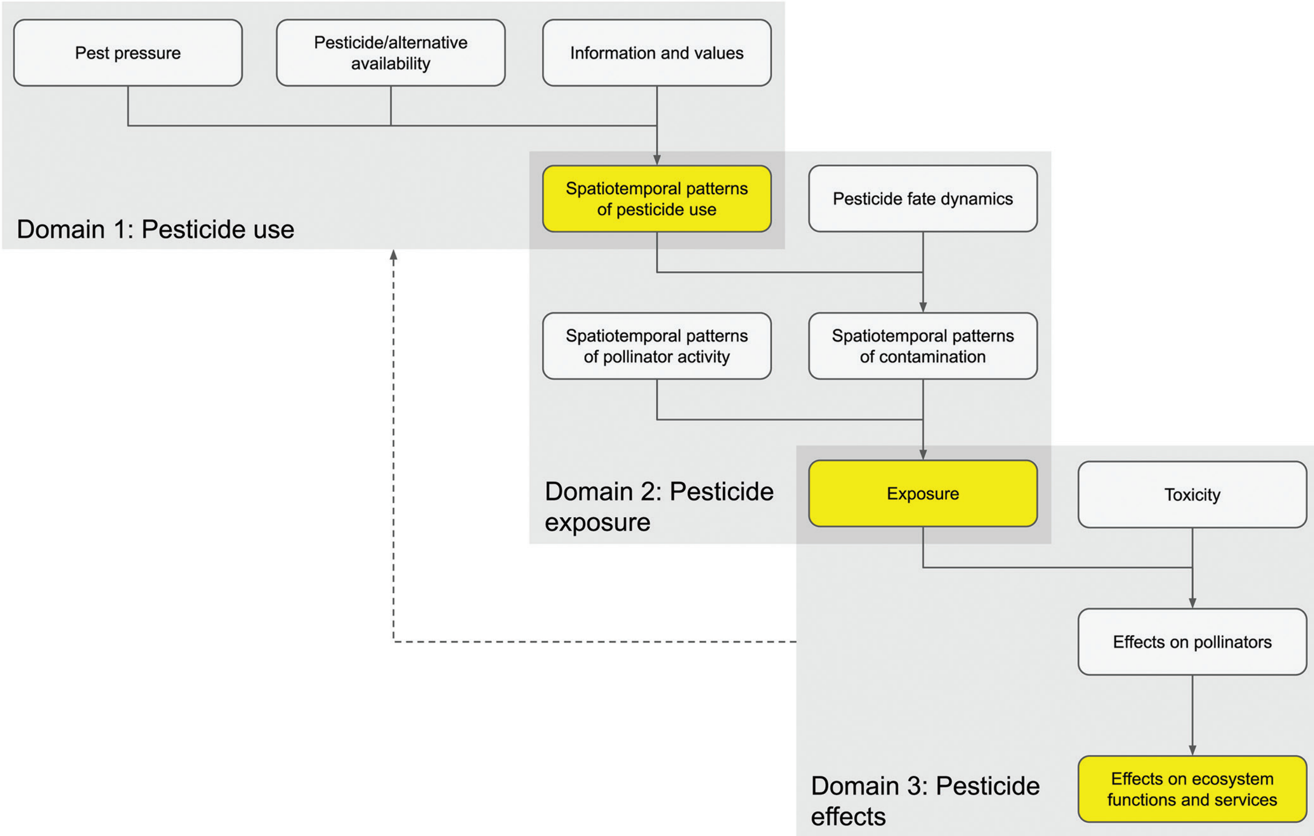

will come into contact with a pesticide, and at what quantity. This is the realm of biology, specifically the field of ecotoxicology.

Next, in Domain 3, patterns of exposure interact with pesticide toxicity to determine effects at the individual, colony, population, and ecosystem levels. It is here that pesticide risk is assessed (which is simply the combination of exposure and effects). Again, this is the realm of biology, often measured via laboratory "effects" assays, and occasionally via ambitious field and semi-field experiments. The idea is to challenge a pollinator with a particular dose of a pesticide, as determined via exposure data, and see whether that dose impacts the organism, colony, population or services provided by the pollinator (e.g., pollination).

Finally (and most importantly), there's a dotted line representing a feedback loop between Domain 3 and Domain 1. This is the realm of government regulatory agencies, extension agents, and engaged stakeholders. To reduce pesticide risk to bees, this feedback loop must occur.

Some members of the National Socio-Environmental Synthesis Center (SESYNC) working group that developed the paper. From left to right: Eric Lonsdorf, Maggie Douglas, Minghua Zhang, Maj Rundlöf, and Christina Grozinger. Photo by Steven Falk

OK, this is all great in theory, but what are some specific things that we can do to make a difference? Sponsler and colleagues outline many areas where efforts can be improved. While all are excellent, I will highlight a few that are perhaps in most need of attention.

First, it's important to understand where applicators obtain pesticide knowledge. In the U.S., the most widely used sources of information are crop consultants, who are often affiliated with chemical sellers and paid primarily via commission. Interestingly, in a study of California almond growers, Brodt et al. (2005) found that growers who used independent crop consultants instead of industry-affiliated crop consultants felt more knowledgeable about integrated pest management (IPM) and used more complex pest monitoring techniques. This study did not find that the level of pesticide use differed for growers that relied on independent consultants vs. consultants affiliated with a seller. However, the differences in knowledge regarding IPM are striking. It's clear that much progress can potentially be made to complement the information distributed from crop consultants affiliated with a seller, especially via University extension agents and independent consultants.

Attendees at the most recent International Pollinator Conference, in 2016 at Penn State. This year's conference will be July 17-20 at UC Davis.

Second, to understand how pesticide use is related to environmental fate and subsequent exposure to pollinators, you first need to know how and when pesticides were used. However, this information is often difficult to obtain in sufficient detail. For example, agricultural pesticide use data are often available only in aggregated forms, such as the annual county- and state-level data maintained by the U.S. Geological Survey's Pesticide Synthesis Project (**https://water.usgs.gov/nawqa/pnsp/usage/maps/index.php**). In other cases, data are aggregated across compounds so that individual active ingredients cannot be traced. And in some regions, data may be lacking entirely or not made publicly available. Sponsler and colleagues highlight the California Pesticide Use Reporting (PUR: **https://calpip.cdpr.ca.gov/main.cfm**) program as an excellent and perhaps unique example of per-field pesticide use that's documented at an hourly temporal resolution. With this information in hand, researchers have a powerful tool at their disposal that can greatly increase knowledge for how and when pesticides remain in the environment, ultimately resulting in exposure to bees. If other states and regions had such databases available, identifying high-risk application practices would be much less of a guessing game.

Finally, remember that dotted line in Fig. 1 that connects Domain 3 to Domain 1? Well, one of the best ways to make sure pesticide knowledge is acted upon is by having engaged stakeholders. Continuing with the California theme for these examples (the 2019 International Pollinator Conference is in California, after all!), it's worth highlighting the relationship between beekeepers and California almond growers. Surveys show that 94% of almond growers coordinate pest control with their beekeepers and 93% of growers provide clean water for bees while they are present in the orchard (Almond Board of California, 2017). Furthermore, new information regarding pesticide risk to bees is rapidly communicated and adopted by growers. For example, the discovery that certain Insect Growth Regulators pose a risk to honey bee larvae and should not be sprayed during bloom quickly resulted in new BMPs and changes in grower behavior (see May 2019 "Notes from the Lab" [*ABJ* 159(5):561-562] for more details). Why? Because growers depend on beekeepers for a successful almond crop, and beekeeper livelihood can strongly depend on the almond pollination event. Thus, all stakeholders are engaged and committed to promoting a safe environment. Can this level of engagement be promoted elsewhere? Absolutely, and tools such as written contractual agreements between beekeepers and growers can encourage mutual accountability.

Sponsler and colleagues have set an excellent agenda and given many examples for how to reduce pesticide risk to bees via a clear, multidimensional approach. Please join us at the 2019 International Pollinator Conference where we'll continue the discussion with biologists, social scientists, regulatory agencies and stakeholders.

Until next time, bee well and do good work,

Scott McArt

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