



If you overuse antibiotics on your bees, your colonies may fail due to inadequate gut microbes.

Nowadays it seems like there's a new paper published every week showing how a robust gut microbiome is critical to honey bee health. Last month, we highlighted a paper showing that gut microbes shape how workers smell, which determines whether they're recognized as colony-mates or intruders. Interestingly, the ability of workers' gut microbes to rapidly change when placed in a new colony may explain why beekeepers can easily swap frames among colonies — the workers pick

up microbes from their new colony fairly quickly and begin to smell like their "new sisters."

But what happens when you change microbes in honey bee guts by killing them with antibiotics, such as those used to treat European foulbrood (EFB) or colonies in the same apiary as a positive American foulbrood (AFB) detection? It's obviously beneficial to kill these serious pathogenic microbes and prevent them from overwhelming hives. But can you do too much of a good thing

and harm bees by killing the good microbes while combatting the bad ones? This is the topic for our thirty-seventh Notes from the Lab, where we summarize "**Long-term effects of antibiotic treatments on honey-bee colony fitness: A modelling approach,**" written by Laura Bulson and colleagues and published in the *Journal of Applied Ecology* [2020,00:1-10].

For their study, Bulson and colleagues used a nice existing dataset in which replicate treatments of ~30 age-controlled workers in hoarding cages were fed 450 µg/ml oxytetracycline (the most common antibiotic used to combat EFB and AFB) in sugar syrup for 5 days. Survival of the bees was monitored daily for 10 days following exposure and compared to controls, to determine how typical oxytetracycline treatment impacted microbiome disturbance and worker mortality over a period of two weeks.

Next, the authors assessed how mortality of individual bees in the short-term experiments could scale up to impact the colony over longer time periods by conducting simulations using the BEEHAVE model (Becher et al., 2014; www.beehave-model.net). BEEHAVE is a mathematical representation of a honey bee colony based on empirical data and accepted theory, and is considered by the European Food Safety Authority (EFSA) as a tool in regulatory risk assessments (EFSA, 2015). The model can be used



Lead author Laura Bulson conducts simulations via the BEEHAVE model to assess the impact of antibiotics on honey bee gut microbiota, mortality, and colony survival.

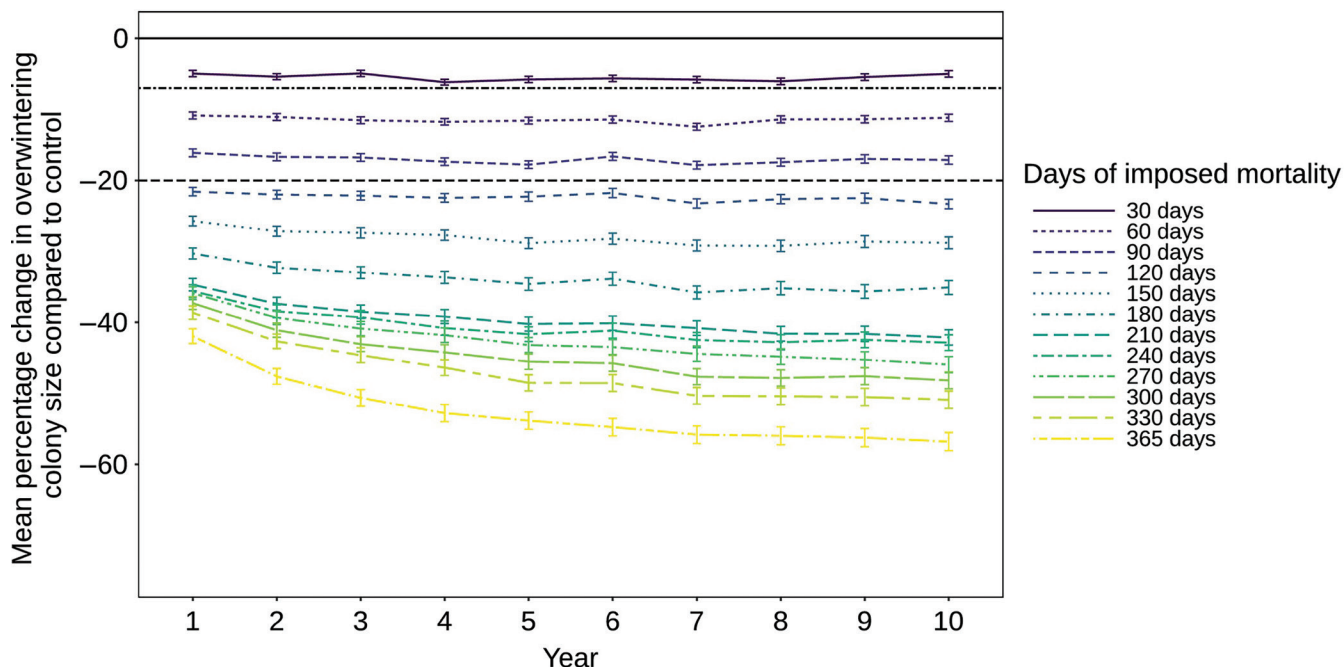


Fig. 1 The mean percentage change in colony size due to antibiotic-induced mortality each year (\pm SE) compared to untreated controls in the same year. Black horizontal solid line corresponds to a zero percent fitness difference. Black horizontal dash-dot line represents the 7% negligible fitness effect cut-off set by the EFSA. Black horizontal dash line represents the 20% economic viability threshold.

to assess how stressors are likely to impact honey bee colonies using various data inputs, such as mortality of individual bees over time in response to antibiotics.

Each simulation of the BEEHAVE model was run with 1,000 mortality values estimated from the existing dataset, resulting in 1,000 replicate simulated colonies per scenario. To increase realism, 10 deformed wing virus-infected and 10 uninfected varroa mites (20 mites total) were added to colonies of 10,000 bees at the start of each simulation, as is standard in EFSA risk assessments. Simulations were run for a period of 10 years to give both short- and long-term estimates of potential impacts of antibiotic use.

Finally, to assess multiple plausible scenarios regarding the duration of microbiome disturbance (because this information is currently unknown), a gradient of antibiotic-induced mortalities was assessed. A 30-day effect duration was considered the minimum scenario and assumes antibiotics only increase a bee's probability of dying during the treatment period (three applications of powdered oxytetracycline 4-5 days apart in the spring and autumn, which some beekeepers are known to use in their hives). This treatment period is similar to the recommendation from U.S. veterinarians when EFB or AFB is found, which

is three applications spaced one week apart.

The maximum scenario (365-day effect duration) assumes gut microbiome depletion following antibiotic exposure is irreversible and results in a permanently increased probability of mortality. While this scenario is unlikely, it is possible. For example, honey bees acquire their core gut microbiome through social transfer, which might be prevented if antibiotics disrupt the microbiome of every individual bee in the colony.

So, what did they find? Is antibiotic treatment likely to impact overwintering colony size? Yes. As can be seen in Figure 1, there was always a negative impact of antibiotics on overwintering colony size (i.e., all simulated scenarios are below the solid black line indicating “no effect” in Figure 1).

However, assumptions regarding the duration of antibiotic impact on the microbiome determine the severity of the problem. If antibiotic treatment only impacts the microbiome for 30 days (solid purple line in Figure 1), the colony experiences a small (<7%) reduction in size that can be considered negligible (EFSA, 2013). If the duration of impact is 90 days or less, the colony diminishes more substantially, but is still under 20%, thus remaining above the economic threshold for beekeepers as deter-

mined via previous work (Thorbeck et al., 2017). However, if the duration of impact is 120 days or longer, colonies fall below this economic threshold.

What about colony survival? Can colonies die from overuse of antibiotics? Yes. But again, assumptions regarding the duration of antibiotic impact determine the severity of the problem. If antibiotics impact mortality for 120 days or less, negligible effects on colony survival occur (Figure 2). However, if the duration of impact is 210 days or longer, between 10-30% loss of colonies can occur after only 5 years, and up to 38% loss can occur after 10 years. (These assumptions are based on the beekeeper routinely treating during spring and autumn over those 10 years.)

So, what does this mean? Should I avoid using antibiotics on my bees? The study from Bulson and colleagues can't go that far in terms of recommendations, but it does raise some excellent points. First, more data are needed to better determine the duration of antibiotic impact on colonies. This is a call to bee researchers to gather more information so we can help beekeepers make more informed decisions! Second, it is very plausible that normal usage of antibiotics can reduce overwintering colony size, and colony loss rates may increase if overuse of antibiotics occurs. Thus, using antibiotics may

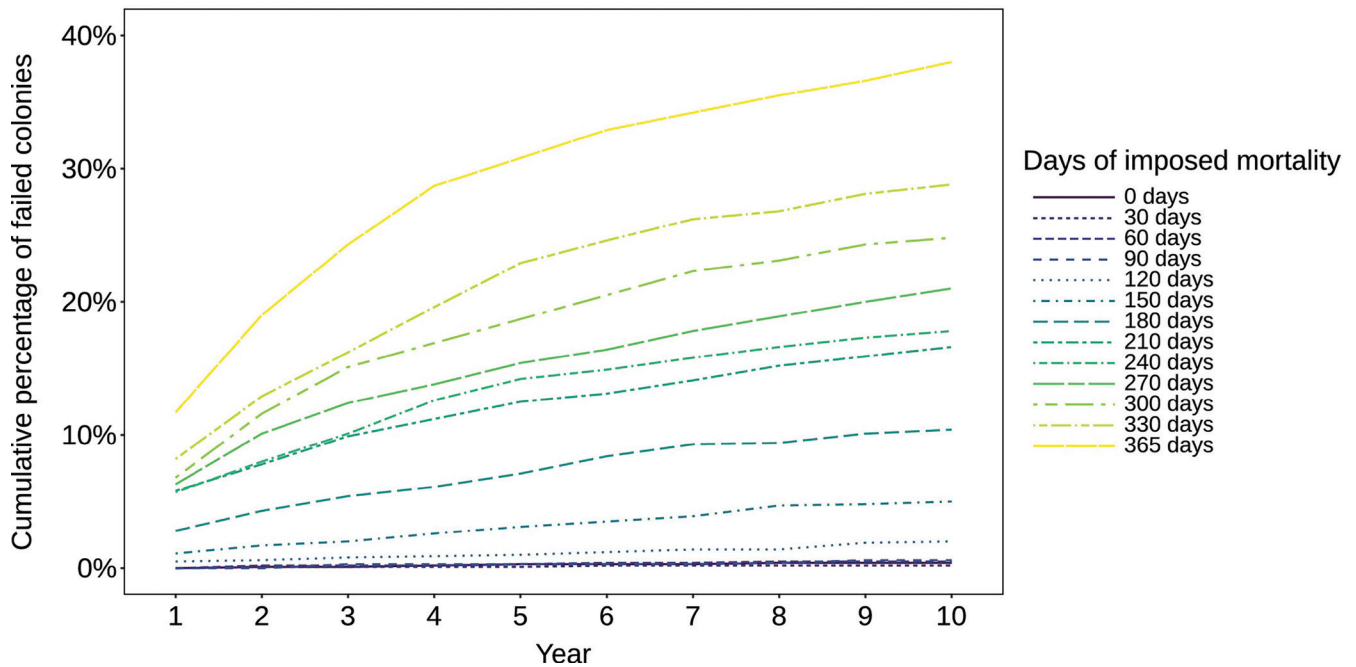


Fig. 2 The cumulative percentage of failed colonies per treatment each year. Colony losses across time are cumulative and the pool of active colonies is progressively smaller with each year.

come with non-negligible risk. In other words, the benefits of using antibiotics must be weighed against the potential costs.

Antibiotics will help when serious outbreaks of EFB occur, and they can also allow peace of mind when used on asymptomatic colonies in an apiary that experiences a positive AFB detection. However, at least for EFB, less-serious spring/summer infections can clear up with a good nectar flow, and re-queening susceptible colonies often helps. In addition, the last thing any beekeeper wants is antibiotic-resistant EFB and AFB, which can occur when beekeepers overuse antibiotics. Given Bulson and colleagues' results, all of these things may be worth considering a bit more seriously before automatically treating colonies.

Finally, it's worth noting that using antibiotics on your bees in the U.S. is only legal if a veterinarian has diagnosed a bacterial infection in your operation and written a prescription. As many beekeepers know, this is an evolving situation since training in honey bee biology is new to veterinary curricula across the U.S. However, until all veterinarians are fully trained in honey bees (trust me, we're working on it!), an excellent way to search for a veterinarian who's comfortable with honey bees and practices near you is via the Honey Bee Veterinary Consortium (<https://www.hbvc.org/>). Please give them a try or contact your state's apiarist

or university extension personnel — we're here to help.

Until next time, bee well and do good work.

Scott McArt

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