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PP-163 [Bee Health]

PROFILING THE BEE GUT MICROBIOME FOR DIAGNOSING NEONICOTINOID EXPOSURE AND MODELING EFFECTS ON COLONY PRODUCTIVITY AND BEEKEEPER PROFITABILITY

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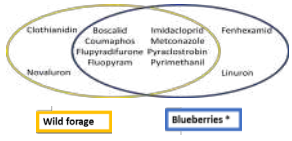
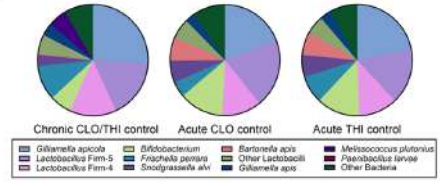
Exposure of the European honey bee (Apis mellifera) to pesticides can result in both lethal and sub-lethal effects that diminish the productivity and sustainability of beekeeping operations. Colonies situated in agriculturally rich regions are often exposed to systemic insecticides. In Western Canada, for example, our findings indicate that colonies are exposed to insecticides regardless of whether they are directly involved in crop pollination.This may be due to widespread pesticide use or dispersion beyond the original application sites. As a result, all beekeepers, including those not renting bees for pollination, may be affected by pesticide exposure to their colonies.

Pesticides found in honey bee bodies
from colonies pollinating blueberries and colonies placed far from blueberries (wild forage) indicating that colonies not involved in crop pollination are also at risk of pesticide exposure in agricultural regions



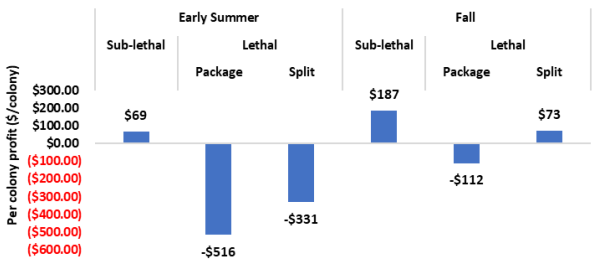
A critical component of colony health is the bee gut microbiome, which plays a vital role in digestion, immunity, and disease resistance. Disruptions in the gut microbial community, or dysbiosis, can serve as early indicators of colony stress and declining health. To better understand how pesticides influence the microbiome, we used shotgun metagenomics sequencing, which allows for deep taxonomic resolution, to assess the gut microbiome's response to two common neonicotinoid insecticides: clothianidin and *thiamethoxam* in laboratory cages and colony field conditions. Our results reveal common dysbiosis signatures, including an increase in *Bifidobacterium* spp. after chronic sublethal exposure and an increase in *Apibacter adventoris* after short-term acute exposure. Other dysbiosis signatures were unique to each insecticide exposure, such as an increase in *Snodgrassella alvi* in response to clothianidin and a decrease in Lactobacillus spp. following thiamethoxam exposure. These microbial shifts reveal the sensitivity of the bee gut microbiome to environmental stressors and highlight its potential as a diagnostic tool for monitoring colony health.

Microbial composition of the gut microbiome of controls bees in the colony experiment (CTX), and control bees in cages for the experiments testing Clothianidin (CLO) and Thiamethoxam (THI)

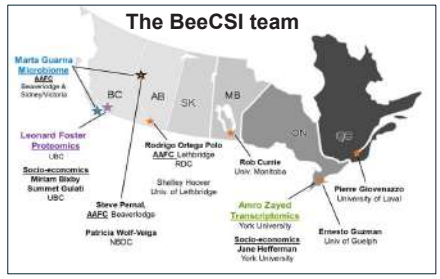


Building on this biological understanding, our research has also examined the economic implications of pesticide exposure for beekeepers. We developed a profit model which incorporates both the direct and indirect effects of neonicotinoid toxicity based on calculated risk quotients (RQs) and exposure thresholds. In this model, direct effects are expressed as a decline in honey production, while indirect toxicity is represented by a colony health variable that influences profitability. The timing of exposure plays a critical role in determining economic outcomes: impacts that occur in the summer, when honey production is highest, result in greater revenue losses compared to those that occur in the fall. While the model highlights significant risks to colony productivity and profitability, it also identifies pathways for mitigation. Practical beekeeper interventions include reducing pesticide exposure and adopting cost-effective replacement and rebuilding strategies such as making in-house colony splits.

Together, these biological and economic insights underscore the importance of integrated strategies for improving honey bee health and maintaining beekeeping profitability in pesticide-intensive agricultural landscapes. Microbiome monitoring and practical beekeeper interventions to minimize pesticide exposure and reduce recovery costs to mitigate profitability losses offer promising avenues for sustaining colony health and maintaining the profitability of beekeeping operations.



Colony profitability considering the impact on honey production from pesticide exposure with no measured adverse effect on other honey bee health or behavior



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PP-163 [Bee Health]
Profiling the Bee Gut Microbiome for Diagnosing Stressor Exposure: The Neonicotinoid Insecticides Example

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The European honey bee (Apis mellifera) plays an essential role in agriculture around the world. In North America alone, honey bees contribute over $20 billion in economic value annually by pollinating crops and producing honey. However, since 2006, North American beekeepers have lost more than a quarter of their colonies each winter. The causes of colony losses are complex, including interacting effects of stressors such as pesticides, nutritional deficiencies, pests, and pathogens. The bee gut microbiome plays a crucial role in colony health and disease, and bee gut microbiome changes, or dysbiosis, can serve as an indicator of bee health status. We are investigating the effect of different stressors on the bee gut microbial community. Here, we report the use of shotgun metagenomics sequencing, which allows for deep taxonomic resolution, to investigate the response of the gut microbial community to two neonicotinoid insecticides, clothianidin and thiamethoxam. Our results reveal common dysbiosis signatures including an increase in Bifidobacterium spp.after chronic sublethal exposure, and an increase in Apibacter adventoris after short-term acute exposure. Other dysbiosis signatures were unique to each insecticide exposure, such as an increase in Snodgrassella alvi in response to clothianidin and a decrease in Lactobacillus spp. following thiamethoxam exposure. These findings deepen our understanding of how the gut microbiome responds to stressors and reveal identifiable microbiome profile signatures. The identification of these dysbiosis signatures highlights the potential utility of honey bee gut microbiome profiling as a diagnostic tool for bee health. Access to timely and accurate bee health diagnostics will inform regulatory actions to reduce exposure to stressors and will facilitate managing and improving bee health.