

Honey Bees:

Nature's Bioindicators for Global Health



Adapted from a blog by Patrick Lester, DVM, MS of the One Health Committee

Honey bees (*apis mellifera* and *apis cerana*) do far more than pollinate crops and produce honey. These industrious insects can also serve as natural sentinels, helping scientists monitor global health challenges such as climate change, antimicrobial resistance, and environmental contamination.

Through their daily foraging activities, honey bees reflect the condition of the ecosystems they inhabit – making them invaluable partners in understanding and protecting our shared environment.

The One Health Connection

The One Health concept recognizes that human, animal, agricultural, and environmental health are deeply interconnected. A threat to one part of this system often affects the others. Among these threats, antimicrobial resistance (AMR) stands out as one of the most pressing global issues.

AMR occurs when bacteria and other microorganisms evolve to resist the effects of antibiotics, making infections harder to treat. Addressing this problem requires collaboration among physicians, veterinarians, farmers, environmental scientists, and policymakers – all working to preserve the delicate

balance between human, animal, plant, and environmental health.

Many professional societies have established stewardship programs and evidence-based guidelines to minimize antimicrobial misuse. Yet, to truly understand the impact of antimicrobial use and resistance on global ecosystems, innovative and accessible monitoring tools are needed.

That's where honey bees come in.

Bees as Environmental Sentinels

Honey bees are uniquely suited to environmental monitoring. Each day, thousands of bees from a single colony travel across miles of terrain, collecting pollen, nectar, resin, and water. In the process, they pick up microscopic particles of everything they encounter – from soil and air pollutants to bacteria and pesticides.

Over time, these materials accumulate within the hive, particularly in the wax, honey, and stored pollen. By analyzing these substances, researchers can detect contaminants such as heavy metals, pesticides, and even genes associated with antimicrobial resistance. This makes bees and their hives powerful 'bio-monitors,' offering insight into the environmental health of large geographic areas.

Honey Bee Health and Disease Dynamics

A honey bee's immune system includes both physical barriers and innate immune mechanisms to fight infection. However, bee immunity is closely tied to the gut microbiota – the community of beneficial microbes that help protect against disease. Antibiotics, pesticides, and pollutants can disrupt this microbial balance, reducing bees' ability to fend off pathogens.

Adult bees are generally resilient, but their larvae are especially vulnerable to bacterial diseases such as *Paenibacillus* larvae (American foulbrood) and *Melissococcus plutonius* (European foulbrood). These infections, often worsened by Varroa mite infestations, can devastate colonies. The mites not only



drain vital nutrients but also transmit viral pathogens, compounding colony stress.

Currently, only a few antibiotics – including oxytetracycline, tylosin, and lincomycin – are approved for treating bacterial infections in bees. Veterinary oversight of antibiotic use through feed directives and responsible prescribing remains a key One Health strategy to limit the emergence of resistance in both bees and the broader agricultural ecosystem.

Pollution, Pesticides, and Subtle Stressors

Honey bee health depends on a complex interaction of internal and external factors. Pesticides, herbicides, and other agricultural chemicals can interfere with bees' ability to forage, care for brood, and maintain colony hygiene – even when exposure levels are too low to cause immediate death.

Studies show that heavy metals and hydrocarbons can accumulate in hives, contributing to chronic stress and reduced colony vitality. Similarly, exposure to pesticides can alter the activity of cellular transporters in bees, reducing antimicrobial concentrations at infection sites and potentially contributing to resistance.



Interestingly, honey itself often contains lower contaminant levels than bees or wax – possibly due to natural filtering mechanisms or differences in how plants absorb pollutants from the soil. Environmental factors such as temperature, precipitation, and local flora also influence bee health and the quality of propolis, the resinous substance bees use as a natural antimicrobial barrier.

Research Challenges and Opportunities

Studying honey bees as environmental indicators is not without difficulty. Bees require open foraging areas and sunlight for navigation, which makes controlled laboratory experiments challenging. Long-term monitoring across seasons and regions is often necessary to capture reliable data.

Because foraging behavior varies by climate and geography, bees may encounter different environmental contaminants, making cross-regional comparisons complex. Co-infections with parasites, bacteria, and viruses can further complicate data interpretation. Despite these challenges, the potential benefits are substantial. Honey bees offer a cost-effective, natural method for tracking environmental quality, antimicrobial resistance trends, and ecosystem changes. Advances in molecular genetics and analytical chemistry now allow for detailed detection of contaminants and resistance genes, opening new frontiers in environmental monitoring.



A Call for Collaboration

As natural bioindicators, honey bees provide vital insights into the health of ecosystems that sustain us all. Their sensitivity to environmental stressors makes them ideal partners for studying the effects of pollution, antimicrobial resistance, and climate change through a One Health lens.

To maximize their potential, coordinated efforts among veterinarians, beekeepers, environmental scientists, and public health professionals are essential. Standardized monitoring methods, data sharing, and collaborative research will strengthen our ability to use honey bees as reliable sentinels of planetary health.

By recognizing and harnessing the power of honey bees, we not only safeguard pollinators but also deepen our understanding of the intricate connections between people, animals, and the environment – the very foundation of One Health. 🐾