USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

How ARS Does It: Prioritizing Animal, Human, Plant, and Environmental Health

Honeybees are important pollinators, and in the United States, honeybees pollinate more than $15 billion worth of crops each year, including fruits, vegetables, nuts, and seeds. Pollination by honeybees and other pollinators can increase yields, improve fruit quality, reduce the need for pesticides, and help prevent the spread of plant diseases. The decline of honeybee populations is a serious threat to food production. There are a number of factors that are contributing to the decline of honeybees, including habitat loss, pesticide use, and climate change.

ARS researchers across the country are evaluating the ecology, distribution, conservation, and effectiveness of insect predators, pollinators, and other beneficial insects. They are also developing alternative honeybee nutritional resources that act as probiotics for the gut microbiome and serve as edible vaccines that boost the honeybee immune system to combat viruses. The following accomplishments in 2022 highlight ARS advances in pollinator health.

New supplemental honeybee diets include algae-based diets. Honeybee colonies managed for agricultural pollination are highly dependent on human inputs, especially for disease control and supplemental nutrition. ARS researchers in Baton Rouge, Louisiana, conducted a large-scale field experiment in collaboration with a commercial beekeeper and showed that the amino acid ratios in various artificial feeds were correlated to honeybee colony performance. This will help inform the industry regarding the need for the development of improved bee feed. They also collaborated with scientists at the University of North Carolina-Greensboro and found that novel microalgae-based artificial diets developed at the Baton Rouge location improved individual honeybee growth and health characteristics. The ARS researchers used bioengineering technologies to develop these microalgae strains to stimulate honeybee immune systems, which effectively enabled the microalgae to function as an edible vaccine (patent pending) that improves resistance to Deformed Wing Virus, a major pathogen responsible for honeybee losses worldwide. Producing these new microalgae strains is scalable to meet the capacity needs of the beekeeping industry, and they can be incorporated into supplemental feed to improve resistance against current and emerging pathogens in managed pollinators. (NP 305)

The source of microbes and pollen is key for bee larval development. Native bee species are a critical component of cranberry production, and bee larvae require microbes to complete their development. ARS researchers in Madison, Wisconsin, showed that the mother bee supplies larvae with a blend of microbes and pollen that is partially derived from her own brood cell and partially derived from the flowers she visits, all of which tend to be conducive to larval growth. To demonstrate the critical importance of this particular microbial seeding, microbes from a different species were substituted as the source of microbes and pollen. Despite having ample pollen and microbes, the fitness of bee larvae that consumed the substitute pollen and microbes declined significantly. This is the first evidence that bees require a particular microbial community and pollen community in their diet, underscoring the importance of microbes for supporting pollinator health. (NP 305)

Two major honeybee probiotics have no long-term effect or efficacy for antibiotic recovery. Antibiotic treatments can greatly distort the honeybee gut microbiome, reducing its protective abilities and facilitating the growth of antibiotic resistant pathogens. Commercial beekeepers regularly apply antibiotics to combat bacterial infections and often use probiotics advertised to ease the impact of antibiotic-induced imbalances in gut microbiota that contribute to poor health (dysbiosis). ARS researchers in Tucson, Arizona, performed a large longitudinal study of commercial honeybee colonies during winter to explore the effects of probiotics and antibiotics. The researchers found the gut microbiome or disease incidence was not affected by probiotic applications or probiotic treatments associated with antibiotic recovery. These results demonstrated the lack of probiotic effect for antibiotic rescue, detailed the dysbiotic states resulting from different antibiotics, and highlighted the importance of the gut microbiome for honeybee health. (NP 305)

Development of novel bee medicines. Various challenges currently facing honeybees and diseases caused by pathogens pose a significant threat to the health and well-being of honeybees. The development of antibiotic-resistant microbes make an already dire situation even worse, so new therapeutic interventions are urgently needed for safe and effective treatments. ARS scientists in Beltsville, Maryland, screened 50 natural products from plants and provided evidence that several compounds, including those commonly found in the pollens and nectars of plants that often attract honeybees, could lead to a significant improvement in immune function and significantly reduce virus levels in bees. These natural products provide a rich source of candidate treatments for bee and hive health. One plant compound, methyl jasmonate, was approved for patenting as a control measure for viral disease. (NP 305)

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