PP-020 [Bee Health]
Defining the Molecular Markers of Honey Bee Health: The Role of Nutrition and Seasonal Dynamics

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Honey bees are essential for ecological balance and agriculture, producing substances beneficial to human health. However, molecular markers of honey bee health remain poorly understood, despite widespread reports of colony collapse. To address this, we studied health markers in Apis mellifera ligustica populations sampled in winter and spring, free from DWV and SBV viruses, by analyzing ten defense-related genes. We also examined the effects of nutrition on overwintered honey bee health in early spring by testing four diets: pollen substitutes Diets 1, 2, and 3, and natural food with bee bread (control). We analyzed diet effects on honey bee metabolism using qPCR to assess ten defense-related and three development- and nutrition-related genes, and monitored virus dynamics in spring. Additionally, we examined protein content and digestibility of the diet proteins using the BCA method. Five molecular health markers were identified: two seasonal markers, domeless and spz, downregulated in overwintering bees, and the task-related marker apid-1, downregulated in both overwintering and newly emerged bees. Two general health markers, SOD1 and defensin-2, were upregulated. Pollen substitute Diet 2, with high protein content and digestibility, significantly improved metabolic health, showing effects similar to bee bread, the optimal food. Machine learning identified six diet-related markers: SOD1, Trxr1, defensin-2, JHAMT, TOR1, and vg. These markers exhibited distinct patterns in bees with chalkbrood symptoms, emphasizing the nutritional impact on health-compromised bees. These findings led to the development of a molecular model describing the transition of healthy long-lived honey bees from diapause to active development, driven by nutrition. The study highlights the interaction of seasonal changes, nutrition, and molecular health markers, offering valuable insights for beekeeping. It also may provide diagnostic tools for monitoring honey bee health during low-temperature months to prevent seasonal losses, with further validation needed across subspecies and climates.