PP-021 [Bee Health]
Improving Honey Bee Health: Analysis of Pollen Substitute Diets in Field and Cage Studies

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Honey bees (Apis mellifera L.) play a crucial role in agricultural pollination and honey production. However, global colony losses are increasing due to multiple stressors, including malnutrition, making the development of effective pollen substitute diets essential for maintaining colony health and productivity. This study evaluated the effects of four different pollen substitute diets (Diet 1, Diet 2, Diet 3, and Control) through both field and cage experiments. A total of 11 parameters and 21 amino acids were analyzed to assess diet performance comprehensively. Among the tested diets, Diet 1 demonstrated the most significant improvements in the field experiment, showing higher honey bee population, brood area, diet consumption, preference, colony weight, and honey production compared to the other diets. Similarly, in the cage experiment, Diet 1 resulted in increased dried head and thorax weight, as well as elevated vitellogenin (vg) gene expression, a critical marker of honey bee health and longevity. Advanced statistical analyses, including canonical discriminant and principal component analyses, highlighted Diet 1's distinct characteristics. Key factors contributing to its superior performance included histidine levels, diet digestibility, consumption rate, vg gene expression, and isoleucine content. Additionally, arginine was found to be significantly correlated with multiple parameters, such as honey bee population, brood area, and consumption, with Diet 1 exhibiting the highest arginine levels. Diet 1's exceptional performance can be attributed to its unique formulation. These findings suggest that Diet 1 could be an effective enhancement for pollen substitute diets, ultimately improving honey bee nutrition, strengthening colony health, and potentially mitigating the impact of malnutrition on global honey bee populations.