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Comparative toxicity of neonicotinoid insecticides to honey bees: insights from a comprehensive network meta-analysis

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Honey bees Apis mellifera are crucial pollinators, playing a key role in the productivity of agricultural crops. However, synthetic insecticides, including herbicides, fungicides, and insecticides, are widely employed in agricultural practices to protect crops from pests and diseases. While these chemicals are effective in controlling pests, they pose several environmental challenges, especially their unintended effects on non-target organisms like bees. The widespread use of neonicotinoid insecticides has raised particular concern due to their potential harm to honey bee populations.

The impact of different neonicotinoid insecticides on honey bee mortality and their overall toxicity levels has not been thoroughly compared. Understanding the relative toxicity of these insecticides can help inform safer agricultural practices and pesticide regulations. This study seeks to compare the toxicity of six neonicotinoid pesticides: Imidacloprid, Clothianidin, Thiamethoxam, Acetamiprid, Thiacloprid, and Dinotefuran, using a network meta-analysis.

A total of 31 studies were included in the network meta-analysis. A Bayesian approach and Markov Chain Monte Carlo (MCMC) simulations were used to analyze the data, with results expressed as log odds ratios (Log ORs) for mortality and Standardized Mean Difference (SMD) for LD and LC values, alongside 95% credible intervals (CrI). The Surface Under the Cumulative Ranking Curve (SUCRA) was employed to rank the toxicity of the neonicotinoids.

The findings indicated that Dinotefuran was the most lethal neonicotinoid for honey bee mortality, with a SUCRA score of 0.76, while Clothianidin, with a score of 0.38, was the least harmful. Regarding LD values, Thiamethoxam was the most toxic (0.76), while Acetamiprid showed the lowest toxicity (0.05). For LC values, Imidacloprid ranked highest in toxicity (0.84), whereas Thiacloprid ranked lowest (0.22). The results highlight the significant variation in toxicity among neonicotinoids.

This analysis emphasizes the need for caution in the use of neonicotinoids in agricultural areas where bees are active. Dinotefuran, in particular, poses a high risk to honey bee populations, while Acetamiprid and Thiacloprid show lower toxicity levels, making them more suitable for bee-friendly pest management strategies. Beekeepers and farmers should consider the varying risks of neonicotinoids when selecting pesticides to minimize harmful effects on bee populations and support sustainable pollination services.