Beta-Cyclodextrin Reduces the Cognitive and Survival Impacts of Imidacloprid Exposure in Honey Bees (Apis mellifera)

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Maintaining healthy honey bee (Apis mellifera) populations is critical for biodiversity and agricultural sustainability. However, neonicotinoid pesticides such as imidacloprid pose significant threats to their survival and cognitive function. To address such challenges, this study investigated the potential of beta-cyclodextrin (beta-CD) to mitigate imidacloprid-induced toxicity by reducing its neurotoxic effects. Three dietary groups were established: a control group (40 wt% sucrose), an imidacloprid-exposed group (5 ppb imidacloprid), and a beta-CD-treated group (5 ppb imidacloprid + 1 mM beta-CD). Over three weeks, beta-CD improved survival by 39.86% relative to the decrease caused by imidacloprid alone, although survival remained 57.8% lower than the control. Imidacloprid impaired associative learning in Proboscis Extension Response (PER) assays and reduced both short-term and long-term memory in the Delayed Matching-to-Sample (DMTS) task, both of which significantly improved with beta-CD administration. Furthermore, in the Positive Transfer of Learning task, beta-CD-treated bees performed better in both training and transfer tests, indicating partial restoration of cognitive flexibility in visual domains. These results suggest that beta-CD may mitigate the adverse effects of imidacloprid in honey bees by limiting its bioavailability. By improving survival and cognitive performance, beta-CD could support colony stability and foraging efficiency, which are essential for sustaining pollination in agricultural ecosystems.

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