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Impact of Organophosphate Insecticides on Sucrose Consumption in *Apis mellifera*

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ABSTRACT

Honeybees (*Apis mellifera*) play a pivotal role in pollinating numerous crops, ensuring both food security and ecological balance. However, their populations face critical threats, including exposure to pesticides. Honeybees were exposed to varying concentrations of chlorpyriphos 20 EC, dimethoate 30 EC, and profenophos 50 EC in sucrose solution. Honeybees consuming chlorpyriphos 20 EC showed the highest intake at a concentration 0.005% (20.48 µl) and the lowest at 0.06% (19.42 µl). Dimethoate 30 EC treated bees had their highest at 0.005% (20.17 µl) and the lowest at 0.07% (19.22 µl). Profenophos 50 EC exhibited its peak consumption at 0.01% (20.05 µl) and the lowest at 0.09% (19.67 µl). In contrast, the control group displayed the highest consumption among all the treatments (24.27 µl). The results demonstrate concentration-dependent alterations in behaviour, with higher pesticide concentrations leading to reduced sucrose solution intake.

Key words: *Apis mellifera, Concentrations, Consumption, Organophosphate, Sugar-syrup*

Introduction

Honeybees, specifically the species *Apis mellifera*, hold a crucial role in pollinating a significant portion of the world's agricultural crops, contributing to global food security and biodiversity conservation. However, in recent years, honeybee populations have encountered substantial challenges, resulting in declines observed worldwide. The indiscriminate use of these organophosphates has raised serious concerns regarding their impact on non-target organisms, particularly honeybees, which may inadvertently come into contact with these toxins while foraging for nectar and pollen. The toxicological effects of organophosphates on honeybees include neurotoxicity, disruption of foraging behaviour, impaired learning and memory, as well as reduced colony growth and productivity (Cresswell *et al.*, 2012; Alkassab and Kirchner, 2017). Our investigation is grounded in a growing body of scientific research that has illuminated the intricate relationship between honeybees and pesticides. This encompasses seminal studies on the adverse effects of pesticides on honeybee health, behavior, and colony dynamics (Decourtye *et al*., 2004; Sanchez-Bayo and Goka, 2014), as well as research into the mechanisms of pesticide toxicity and metabolism in bees (Johnson *et al*., 2010; Tosi *et al*., 2017).

Materials and Methods

Young adult worker bees (*A. mellifera*) of approximately the same age and feeding condition were collected from the apiaries of the FoA, Wadura, SKUAST-K, and RCFC NR-II and transferred to the division of entomology laboratory. The bees were transferred from glass flasks to the test cages for acclimation. To ensure that all bees had uniform gut contents at the beginning of the experiment, the bees were starved for two hours before the treatment. However, prior to the commencement of the test, dead bees were removed and replaced with healthy ones. Various concentrations of the test insecticide chlorpyriphos 20 EC @0.005%, 0.01%, 0.02%, 0.04% and 0.06%, dimethoate 30 EC @0.005%, 0.01%, 0.03%, 0.05% and 0.07% and profenophos 50 EC @0.01%, 0.03%, 0.05%, 0.07% and 0.09% were taken in the specially designed glass tubes (15 cm length, 0.8 cm diameter) with 0.2 cm bore on one side of the tube and hung from the top of the cages about 2.5 cm above the bottom. The insecticides were applied with 500 g/l sucrose (50% w/v) as the food source. The level of insecticide-sugar-water solution, in glass tubes, was so adjusted that only the proboscis of the bees could reach the solution, preventing any other body parts from making contact with it. After an hour of feeding, the latter were replaced by thirty per cent sugar-water solution for further feeding. Consequently, unconsumed treated diet were replaced with the sucrose solution alone, after a maximum of 6 hours. The control group was provided with a sucrose solution with no insecticide added. The amount of treated diet consumed were assessed as: Measurement of volume/weight of treated diet remaining. The quantity of consumed food was measured after 6 hours, by weighing the liquid foods remaining in the feeder vials, and as compared to theweight of the full feeder at the start.

Results and Discussion

The results of the study investigating the impact of various concentrations of chlorpyriphos 20 EC, dimethoate 30 EC, and profenophos 50 EC on pesticide-loaded sucrose solution consumption by honeybees (*Apis mellifera*) are summarized in the Table 1 and Figure 1. The table presents mean consumption data (in µl) for honeybees exposed to different concentrations of these organophosphate insecticides. These comparisons highlight the variations in

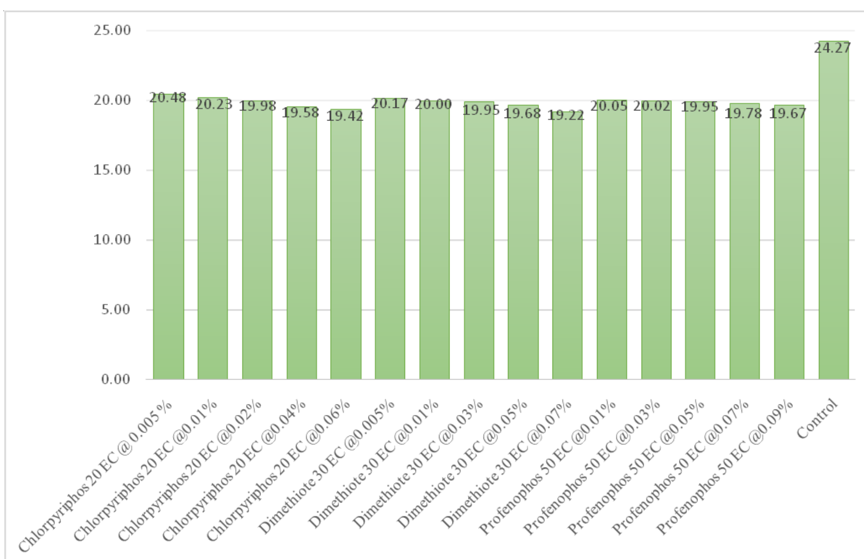

Fig. 1. Intake of sucrose containing organophosphate pesticides (in µL) by worker bees following a six-hour exposure.

sucrose solution consumption by honeybees in response to different concentrations of pesticides. The highest concentrations generally results in reduced consumption compared to the lowest concentrations or the control group, thereby suggesting potential effects of these pesticides on honeybee behaviour. For chlorpyriphos 20 EC, the highest consumption (0.005% concentration) was 20.48 µl, while the lowest consumption (0.06% concentration) was 19.42 µl. Similarly, for dimethoate 30 EC, the highest consumption (0.005% concentration) was 20.17 µl, whereas the lowest consumption (0.07% concentration) recorded 19.22 µl. For profenophos 50 EC, the highest consumption (0.01% concentration) measured 20.05 µl, and the lowest consumption (0.09% concentration) was 19.67 µl. In the Control group (no pesticide), the honey bees consumed 24.27 µl of solution, which surpasses all other treatments. Our study demonstrates that honeybees exposed to higher concentrations of organophosphate insecticides exhibit a propensity to reduce their sucrose solution intake compared to those exposed to lower concentrations or the control group. This reduction in sugar syrup consumption indicates altered foraging behavior, possibly driven by the sublethal effects of pesticides. Prior research has highlighted that exposure to neurotoxic pesticides can impair the cognitive and sensory functions of honeybees, affecting their ability to locate and collect food resources (Decourtye *et al*., 2004; Johnson *et al*., 2010). The observed reduction in sugar syrup consumption among honeybees exposed to higher concentrations of organophosphates aligns with studies that have identified sublethal effects of these pesticides. For example, neonicotinoid pesticides, a chemical class with some similarities to organophosphates, have been linked to impaired foraging behaviour, reduced navigation abilities, and reduced homing success in honeybees (Henry *et al.*, 2012; Fischer *et al*., 2014). Such sublethal effects can disrupt the intricate foraging activities of honeybee colonies and compromise their ability to gather resources efficiently.

Conclusion

The investigation into sugar syrup consumption by honeybees exposed to various concentrations of organophosphate insecticides provides valuable insights into the potential impact of these chemicals on honeybee behaviour. The observed variations in sucrose solution among different pesticide concentrations underscore the sensitivity of honeybees to organophosphates and their potential sub lethal effects. Our findings suggest that higher concentrations of organophosphate insecticides can lead to reduced sucrose solution consumption by honeybees. This altered foraging behaviour has significant ecological implications. Reduced nutrient intake can

Table 1. Intake of sucrose containing organophosphate pesticides (in µL) by worker bees following a six-hour exposure.

Chemical	Concentration (%)	Mean (µl) ± S.E.	Minimum	Maximum	Mean (µl)	Confidence Level (95.0%)
Chlorpyriphos 20 EC	0.005	*409.67±0.88	408.00	411.00	**20.48	3.79
	0.01	404.67±1.77	402.00	408.00	20.23	7.59
	0.02	399.67±2.33	396.00	404.00	19.98	10.04
	0.04	391.67±1.20	390.00	394.00	19.58	5.17
	0.06	388.33±0.66	387.00	389.00	19.42	2.87
Dimethoate 30 EC	0.005	403.33±1.45	401.00	406.00	20.17	6.25
	0.01	400.00±2.65	396.00	405.00	20.00	11.38
	0.03	399.00±0.58	398.00	400.00	19.95	2.48
	0.05	393.67±1.20	392.00	396.00	19.68	5.17
	0.07	384.33±0.88	383.00	386.00	19.22	3.79
Profenophos 50 EC	0.01	401.00±1.16	399.00	403.00	20.05	4.97
	0.03	400.33±0.66	399.00	401.00	20.02	2.87
	0.05	399.00±0.58	398.00	400.00	19.95	2.48
	0.07	395.67±0.67	395.00	397.00	19.78	2.87
	0.09	393.33±1.45	391.00	396.00	19.67	6.25
Control	0	485.33±0.88	484.00	487.00	24.27	3.79

*Sucrose solution consumed per replication, ** sucrose solution consumed per bee compromise individual bee health, potentially weakening colonies and rendering them more susceptible to other stressors.

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