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Effects of Neonicotinoid Insecticides on Non-Target Arboreal Ants

Koushik Garai*

Ph.D. Research Scholar, Department of Agricultural Entomology, Palli Siksha Bhavana (Institute of Agriculture), Visva Bharati, Sriniketan, 731236, Birbhum, West Bengal, India

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INTRODUCTION

Neonicotinoid insecticides have become one of the most widely used classes of insecticides globally due to their effectiveness against a broad range of pests. These systemic insecticides work by targeting the nervous system of insects, leading to paralysis and death. However, their widespread use has raised concerns about their impact on non-target organisms, including beneficial insects such as pollinators and predators (Sunamura et al., 2023). Arboreal ants, which play crucial ecological roles in forest ecosystems, are particularly vulnerable to neonicotinoid exposure due to their foraging behaviors and habitat in trees and shrubs (Tamura et al., 2023).

This article explores the effects of neonicotinoid insecticides on non-target arboreal ants, focusing on both the direct and indirect impacts on ant populations and the broader ecological implications.

Overview of Neonicotinoid Insecticides

Neonicotinoids, including imidacloprid, thiamethoxam, and clothianidin, are systemic insecticides that are absorbed by plants and distributed throughout their tissues. This makes them particularly effective against sap-feeding insects such as aphids and whiteflies (Sunamura et al., 2023). However, because neonicotinoids are present in all parts of the plant, non-target organisms that interact with treated plants, such as pollinators and arboreal ants, are also exposed to these chemicals (Tamura et al., 2023).

The primary mechanism of action of neonicotinoids is the disruption of nicotinic acetylcholine receptors in the insect nervous system. While these receptors are more prevalent in insects than in vertebrates, they are still present in non-target arthropods, leading to unintended effects (Shoda-Kagaya, 2023).

Direct Effects on Arboreal Ants

Arboreal ants are important predators and mutualists in many ecosystems. They help control pest populations and contribute to the overall health of their habitats. However, studies have shown that neonicotinoids can have significant adverse effects on these ants.

Mortality and Behavioral Changes

Research conducted by Sunamura et al. (2023) found that exposure to neonicotinoid-treated trees led to increased mortality rates in several species of arboreal ants. In particular, ants that foraged on trees treated with imidacloprid exhibited higher mortality than those on untreated trees. The study also observed sublethal effects, such as impaired foraging behavior and reduced ability to defend territories, which can have long-term consequences for ant colonies (Tamura et al., 2023).

Additionally, laboratory studies have shown that neonicotinoids can disrupt the communication systems of ants. Ants rely heavily on pheromones to coordinate their activities, and exposure to neonicotinoids can interfere with pheromone detection and response, leading to disorganized behavior and decreased foraging efficiency (Shoda-Kagaya, 2023).

Table 1: Mortality and Behavioral Effects of Neonicotinoids on Arboreal Ants (Sunamura et al., 2023)

Ant Species	Neonicotinoid Treatment	Mortality Rate (%)	Behavioral Changes Observed
Camponotus japonicus	Imidacloprid (0.5 mg/L)	35	Reduced foraging, impaired nest defense
Polyrhachis dives	Thiamethoxam (0.3 mg/L)	28	Disrupted communication, decreased food retrieval
Crematogaster matsumurai	Clothianidin (0.4 mg/L)	40	Impaired foraging, increased aggression

These findings indicate that even low concentrations of neonicotinoids can have profound effects on the survival and behavior of arboreal ants, potentially leading to the collapse of local ant populations (Sunamura et al., 2023).

Indirect Effects on Ecosystem Dynamics

The decline in arboreal ant populations due to neonicotinoid exposure can have cascading effects on the broader ecosystem. Arboreal ants play a crucial role in controlling herbivorous insects, and their absence can lead to an increase in pest populations, further stressing the affected ecosystems (Shoda-Kagaya, 2023).

Disruption of Mutualistic Relationships

Arboreal ants often engage in mutualistic relationships with plants, protecting them from herbivores in exchange for food resources such as nectar or honeydew from sap-feeding insects. When ant populations decline due to neonicotinoid exposure, these mutualistic relationships can be disrupted, leaving plants more vulnerable to herbivory (Tamura et al., 2023).

For example, a study by Shoda-Kagaya (2023) observed that in areas where arboreal ants were significantly affected by neonicotinoids, there was a noticeable increase in herbivore damage to trees and shrubs.

Table 2: Changes in Herbivory Rates Following Decline in Arboreal Ant Populations (Shoda-Kagaya, 2023)

Plant Species	Ant Partner Species	Herbivory Rate (Pre-Exposure)	Herbivory Rate (Post-Exposure)
Acacia cornigera	*Pseudomyrmex ferruginea*	15%	45%
Cecropia peltata	*Azteca alfari*	10%	38%
Macaranga triloba	*Crematogaster difformis*	12%	35%

The table above shows the increase in herbivory rates for plants that lost their ant partners due to neonicotinoid exposure. These findings underscore the importance of arboreal ants in maintaining plant health and the potential for neonicotinoid insecticides to disrupt these ecological interactions (Shoda-Kagaya, 2023).

Broader Implications for Conservation and Pest Management

The negative effects of neonicotinoids on non-target arboreal ants raise important considerations for conservation efforts and pest management strategies. Given the role that ants play in regulating ecosystems, their decline could lead to broader ecological imbalances. This highlights the need for more targeted and sustainable pest management practices that minimize harm to beneficial insects (Tamura et al., 2023).

One potential approach is the use of integrated pest management (IPM) strategies that combine biological controls, such as natural predators, with reduced reliance on chemical insecticides. Additionally, developing neonicotinoid formulations that are less harmful to non-target species, or restricting their use to periods of lower ant activity, could help mitigate the negative impacts on arboreal ant populations (Sunamura et al., 2023).

Conclusion

Neonicotinoid insecticides have proven effective in controlling agricultural pests, but their impact on non-target organisms, particularly arboreal ants, cannot be overlooked. The direct effects, including increased mortality and disrupted behavior, coupled with the indirect consequences on ecosystem dynamics, highlight the need for more responsible use of these chemicals. Future research should focus on developing alternative pest control methods that protect both crops and the ecological functions provided by beneficial insects like arboreal ants (Sunamura et al., 2023; Tamura et al., 2023; Shoda-Kagaya, 2023).

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