

Earth & Space

Honeydew: the sweet that can become toxic

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ABSTRACT

Neonicotinoids reach and kill beneficial insects when they feed on honeydew. Honeydew is the excretion product of phloem-feeding hemipteran insects such as aphids, mealybugs, whiteflies, or psyllids. This route of exposure is likely to affect a much wider range of beneficial insects and crops than contaminated nectar. Therefore, it should be included in future environmental risk assessments of neonicotinoids.



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Recent studies have demonstrated that insect populations are in decline. These declines represent serious concern because of the valuable ecosystem services provided by beneficial insects, such as pollination, biological control, nutrient cycling, and providing food sources to higher trophic levels in the food web. One of the leading causes of this decline is the overuse of pesticides in agriculture. In particular, neonicotinoids are widely used in many important crops. Their use is questioned because of their high toxicity on beneficial insects, especially pollinators and biological control agents of insect pests. One of the best-known routes of neonicotinoid exposure is contaminated nectar and pollen. Neonicotinoids are systemic insecticides that translocate to nectar and pollen. Many beneficial insects feed on these

carbohydrate sources and, therefore, are exposed to neonicotinoids. However, modern agriculture is mainly based on vast monocultures. There, nectar is scarce for beneficial insects for several reasons. The flowering period is brief. Some crops such as leafy green vegetables, artichokes, carrots, leeks, onions, etc. are harvested before the flowering period. Absence of alternative habitats. Few crops have extrafloral nectaries. In these agroecosystems, honeydew represents the most abundant and accessible source of carbohydrates for beneficial insects, including bees, ants, parasitic wasps, and predators. Honeydew is the sugar-rich excretion of phloem-feeding insects such as aphids, whiteflies, mealybugs, coccids, and psyllids that feed on crops, weeds, and surrounding vegetation. Most of the

major crops on Earth (cereals, soybean, cotton, citrus, apples, potatoes, etc.) are hosts to these phloem-feeding insects. They excrete honeydew to the ecosystem while they are feeding on plants treated with neonicotinoids. This pathway of insecticide exposure, however, had not been explored. We tested this potential route of exposure to neonicotinoids in collaboration with an international multidisciplinary group of researchers. The team included ecologists and chemists specialized in insecticides.

To prove this hypothesis, we studied the hoverfly *Sphaerophoria rueppellii* and the parasitic wasp *Anagyrus pseudococci*. They were fed *ad libitum* with honeydew excreted by the mealybug *Planococcus citri* settled on citrus trees. Infested trees were treated with the neonicotinoids thiamethoxam and imidacloprid under two potential scenarios. To test the most common mode of application, insecticides were applied via the soil at the recommended concentrations. In a second scenario, we applied insecticides as a foliar spray at 50% of the recommended concentrations. We did this to test the effects when low doses of neonicotinoids reach honeydew producers. This second scenario was set up to represent exposure through 1) insecticide drift to untreated plots, 2) partial exposure to insecticide when a spray does not reach all parts of the plant due to incorrect insecticide application or unfavorable climatic conditions, or 3) when neonicotinoids remain in the plant for long periods at lower concentrations (keep in mind that neonicotinoids can remain in the plant for months!).

All of the hoverflies that fed on honeydew from trees sprayed with thiamethoxam [died within three days](#), while just 10% of the control group died. In the soil-treated trees, nearly 70% of the hoverflies died from the same chemical, compared with about 14% in the control group. A similar result, although with lower toxicity, was obtained for the parasitic wasps. In this case, more than half of the wasps died after feeding on honeydew from the soil-treated and sprayed trees with thiamethoxam. In contrast, less than 20% died in the controls. Thiamethoxam resulted in higher toxicity than imidacloprid. This was likely because thiamethoxam is a phloem-transported insecticide, and imidacloprid is translocated mostly via xylem. Therefore, phloem feeders such as *P. citri* are more likely to excrete thiamethoxam in their honeydew.

The wide use of neonicotinoid insecticides in all crops and the ubiquitous presence of honeydew in these crops suggest that contaminated honeydew might be a serious threaten for beneficial insects. In fact, recent studies have detected neonicotinoids in 93% of organic soils and crops that had not been treated with neonicotinoids for the last ten years. Therefore, honeydew could be the agriculture's poison apple for beneficial insects (or a sweet that can become highly toxic to beneficial insects). For these reasons, we call for a reduction in the overuse of neonicotinoids to revert damaging effects on the biodiversity and the ecosystem services provided by beneficial insects.