Bees & Pesticides: Science Update

The evidence linking pesticides with bee declines continues to grow.

With pollinators required for 30% of the human food supply[1], negative impacts on bee populations could lead to decreased reliability and diversity in food production.

Bees are frequently exposed to a "chemical cocktail" of pesticides used in homes and gardens, in beehives and on public lands—but the largest percentage of bee-harming chemicals are used in agriculture. As industrial farming continues to rely on neonicotinoids, fungicides and other pesticides known to threaten pollinator health, the dramatic bee declines we've seen in recent years will likely continue. Many studies have identified a wide range of effects on bees due to widespread pesticide exposure, impacting behaviors vital to survival like foraging, homing and navigation, and immunity to common pathogens. In short, bees are in trouble.

Multiple exposure routes

Bees are often exposed to pesticides via multiple routes. With the widespread usage of pesticides in many settings, a beehive free of contamination is a rarity. A total of 161 different pesticide residues have been detected in samples taken from beehives worldwide.[2,3,4] A recent review of several hive tracking studies from the U.S., France, Spain, and Poland found the highest residue concentrations in wax and pollen.[5]

In a study of 19 hives associated with seven different fruit, nut and vegetable crops, all 19 pollen samples taken from the hives were contaminated with both insecticides and fungicides, with herbicides present in 23.6% of the samples. When pollen collected from the crop fields was fed to the bees, they showed an increased susceptibility to infection by the gut pathogen *Nosema*.[6]

Neonicotinoid, or neonic, residues and other pesticides have been detected in a number of sources. They've been found in plants, nectar and guttation droplets (like dew), pollen, bee bread (honey or pollen for bee food), dust from treated seeds, and in the bees themselves.[5,7-11]

Conventional and genetically engineered corn seeds are often coated in neonics, and corn guttation droplets have been shown to include bee-toxic levels. However, this appears to be a limited source of exposure as honey bees tend to collect water from vegetation sources other than corn.[8,11,13] But neonics have been shown to contaminate puddle water in corn fields at levels associated with sublethal effects on honey bees, and anecdotal observations have been made of bees drinking from these puddles.[12] Other kinds of pollinating insects may also collect guttation droplets as a primary water source, and this route of exposure poses a likely threat to them.[13]

161 different pesticide residues detected in hives.

The problem of pesticide-coated seeds

Prophylactic seed coatings, or seeds treated with pesticides before planting, account for the most of the neonicotinoid insecticides used in the U.S.[13] Because they are water-soluble, neonicotinoids get taken up by the plant's vascular system and are distributed throughout the plant.

Neonics and other pesticides in seed coatings are also released into the environment via the dust generated when treated seeds are sown—and this dust has been shown to be toxic to bees. [9-11,14]

Widespread use of neonics in seed coatings for soybeans and corn has also resulted in pervasive neonic contamination of surface waters in the U.S. [15,16] The time span between the first application of a pesticide and its appearance in groundwater is on average 20 years. Thus, future detections of neonicotinoids in groundwater are basically inevitable. [18]

Neonics are also found in soils after treated seeds have been planted. As these chemicals bind to soil particles, persistence in soil can occur for up to three years.[17]

Even though much of the corn and soy planted in the U.S. is treated with neonics and other pesticides, seed coatings may have little economic justification. In 2014, the Environmental Protection Agency (EPA) released an evaluation of coated soybeans that stated: "... in comparison to the next best alternative pest control measures, neonicotinoid seed treatments likely provide $0 in benefits to growers." [19]

Small doses, sublethal effects

Sublethal doses (i.e., below those causing death) of neonicotinoids can cause a range of effects, including changes in brain structure that negatively impact vision, disruption of organs or functions essential to survival, and disruption of brain functions associated with navigation. [20,21]

In a recent field study, exposure to two neonics at sublethal doses resulted in a significant decrease (23-29% less) in bees successfully returning to the hive after being displaced a short distance from it. A significant decrease in successful returns to the hive was also shown with exposure to a pyrethroid insecticide. [22]

Sublethal exposure to the widely used neonic imidacloprid resulted in the damage or death in parts of honey bees' brains that are used for learning and memory. Optical lobe damage, which likely impacts visual acuity and thus the bees' ability to forage effectively was observed at all doses studied. This suggest that these structures are much more sensitive to exposure than the rest of the brain. [23]

Even small doses of pesticides can impair key functions bees need to survive. And in the field, bees often encounter multiple exposures of one or more pesticides.

Chemical cocktail

Examining the effects of multiple chemical exposures is more representative of what bees actually experience, and should be prioritized for further study.[5]

In two recent studies, increased toxicity was observed when bees were exposed to both insecticides and fungicides. In one study, neonics in the presence of two different fungicides had a 105-fold to a 1,141-fold increase in toxicity to honey bees than when measured alone.[24] Synergistic effects were also identified between fungicides and a pyrethroid insecticide, using amounts based on application rates recommended for tank-mixing in field applications.[25]

Bees are exposed to herbicides, fungicides, insecticides and more, through multiple sources. All of this occurs with little to no monitoring from EPA on how all of these chemicals interact to impair bee health.

The presence of *both* neonics and fungicides increased toxicity by 1,141-fold.

And there's more: Surfactants

Yet another aspect of toxicity and interactions is found in pesticide additives, such as surfactants. A pesticide's active ingredients are regulated, but pesticide additives are not—and are frequently kept confidential by pesticidemakers.

Surfactants reduce surface tension between liquids and can increase solubility of compounds in a mixture. Testing surfactant toxicity, researchers found several surfactants to kill honey bees at field rates of application.[26] The presence of certain surfactants in pond water has also been shown to repel honey bees from visiting contaminated ponds.[27]

When researchers sampled U.S. beehives for surfactants and pesticides, they found 70% of the pesticides sampled for, and 100% of the surfactants they tested for, indicating widespread contamination by surfactants in the hives. At field-realistic doses, some surfactants have been shown to be harmful to bee larvae and to impair learning in adult bees.[28] These findings are particularly alarming because so called "inert" chemicals are not regulated in pesticide formulations.

More than just honey bees

The value of insect pollinators' contribution to agriculture around the world has been estimated $215 billion.[29] Wild insect pollinators alone also play a significant role in agriculture, with a 2013 study finding universally positive associations in fruit yields after flower visitation by wild insects in 41 crop systems worldwide. Pollination by honey bees further supplements wild insect pollination.[30] And in some cases, wild bees alone have been known to fully pollinate crops.

Results from studies like these suggest that farming practices that both integrate management of honey bees and promote diversity of wild insect species would enhance crop yields worldwide.

In a recent meta-analysis of over 90 studies, mainly from Europe and North America, organic farming increased biodiversity on farms by about 30%, with pollinator biodiversity making significant gains from organic farming.[31] Bringing biodiversity into intensive agricultural areas with practices such as hedgerow restoration, and minimizing or eliminating pesticide exposure among honey bees and wild pollinators, would certainly enhance pollination services overall.

We need bees & they don't need pesticides

The science is clear. Independent studies confirm that certain pesticides are harming bees and other pollinators, showing that:

- **Sublethal exposure to neonics can damage bees' brains;**
- **Pesticides of different types can have a negative impact on functions essential to bee survival; and**
- **Other "inert" ingredients in pesticide formulations have been shown to kill bees and may have other deleterious effects.**

Policy recommendations

1. **EPA and USDA** should increase fees paid by pesticide manufacturers associated with seed coatings, to fund sustainable and successful farming practices and tools, and in conjunction with existing conservation and incentive programs.
2. **Congress** should place an immediate moratorium on neonicotinoids and related systemic insecticides, and increase investments in green, fair and cutting-edge alternatives.
3. **States and EPA** should suspend registrations of neonicotinoids and similar systemic insecticides.
4. **States and USDA** should set targets for significant reductions.
5. **Cities or counties** should show leadership by passing a resolution or ordinance to become a "Honey Bee Haven."

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A well-known bee researcher recently noted that,

> *Bee declines are driven by combined stress from parasites, pesticides and lack of flowers.*[32]

Pesticides are a key factor contributing to bee declines and meaningful action to protect these vital pollinators is crucial.

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