EPA Confirms Honey Bee Exposure to Hazardous Pesticides

Five take-home messages on EPA's long-awaited preliminary pollinator risk assessment of the neonicotinoid imidacloprid

Photo by Anneliese Markle.

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As the pollinator crisis continues, calls for the suspension of bee-toxic pesticides have gone ignored by U.S. regulators. Instead, the U.S. Environmental Protection Agency (EPA) promised to fast-track its review of the neonicotinoid (neonic) class of chemicals, a group of systemic insecticides that contaminates the entire plant, including pollen and nectar, is highly toxic to bees, and contributes significantly to pollinator decline.

In early January 2016, EPA released its long-awaited preliminary pollinator assessment for the neonicotinoid imidacloprid, a review process it began in 2008. The assessment, a joint review effort with Health Canada's Pest Management Regulatory Agency (PMRA) and the State of California's Department of Pesticide Regulation (CDPR), is the first of several neonic assessments scheduled to be released this year. The findings of EPA's 300-plus page assessment are not surprising –imidacloprid is highly toxic to bees, and contaminates nectar and pollen of crops to which bees are exposed. While EPA acknowledges that bees can be exposed through various pathways, including soil, surface water and guttation droplets, the agency notes that it lacks the information to understand and quantify the risks from these exposure routes. The high degree of uncertainties that are cited in this assessment and potentially in the revised version supports advocates' position that EPA should take action to remove imidacloprid from the market.

What follows are the major take-aways from this latest assessment and what can be expected from the other neonic reviews due out at the end of 2016.

1. Imidacloprid Toxicity to Bees Is Undisputed

EPA establishes that for acute (short-term) and chronic (long-term) exposures imidacloprid is classified as *very highly toxic* to individual adult honey bees with an acute oral LD50 value of 0.0039µg/bee (micrograms) and an acute contact LD50 value of 0.043 µg/bee, with chronic impacts observed around 0.00016 µg/bee. These levels demonstrate just how highly toxic imidacloprid is to honey bees.

Significant Increase in Imidacloprid Use

From 1998 to 2012, the land area treated with imidacloprid grew from five million to 30 million acres, a six-fold increase. According to EPA, this increase occurred as a result of a massive expansion of neonic use in seed coatings for grain crops like soybeans and wheat, in addition to foliar applications and seed coatings in specialty crops, such as cherries, apples, carrots, and cauliflower. Application of imidacloprid is mainly via foliar and soil applications (including seed coatings).

Impacts to the colony are manifested in the "reduction in number of worker bees available for foraging or maintaining hive temperature (during over-wintering), reduction in foraging efficiency via sublethal effects on workers, decreased number or delayed development of brood either from direct exposure or indirectly from reduced brood feeding and maintenance by hive bees, and reduced fecundity and survival of queens." Contaminated nectar brought back to the colony lead to reduced adult workers, numbers of pupae, pollen stores and honey stores. For the colony, EPA finds the highest nectar residue level at which no effects (No Observed Adverse Effect Level or NOAEC) were observed in honey bees is 25 ppb, while the lowest level (Lowest Observed

The Honey Bee Continues To Be the Surrogates for Risk Assessment

EPA's imidacloprid assessment focuses on impacts to the honey bee (*Apis mellifera*), even though other bee species are oftentimes more sensitive to exposures. EPA reasons that it is the honey bee that has a dominant role in providing managed pollination services for agricultural crops. For the assessment, the agency looked at effects related to development, growth, survival and reproduction of the individual bee, as well as the colony.

Glaringly, despite this being called a "pollinator risk assessment," no mention is made of other insect pollinators like the butterfly, especially the Monarch butterfly, which has seen precipitous losses over the last 10 years.

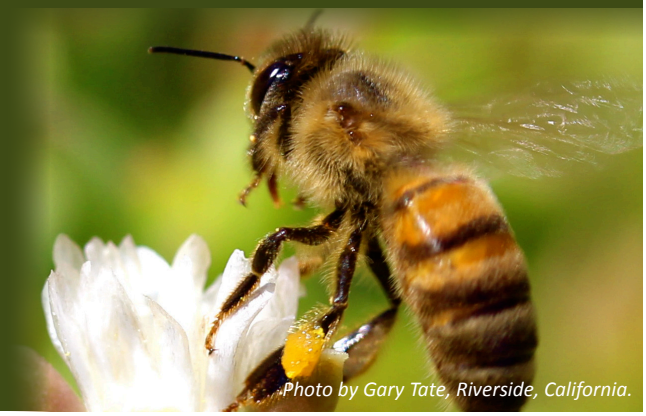

Photo by Gary Tate, Riverside, California.

Table: EPA Preliminary Risk Findings Conflict with Independent Science, Confirm Exposure to Bees

EPA's crop by crop analysis of imidacloprid belies important real-world additive and interactive exposure pathways that underscore a need for a more holistic approach to understanding the impact of neonicotinoid contamination.

Summary of EPA's Findings for honey bee exposure to crops on-field		Studies demonstrate that neonicotinoid contamination is pervasive across landscapes and warrants a cumulative ecological assessment:	
Low Risk to Bees	All application methods of root/tuberous, bulb, leafy greens, and brassica vegetables, globe artichoke, and tobacco (harvested before bloom). Soil applications to blueberries (berries and small fruits). Seed treatment to corn and other cereal grains: wheat, barley, oats, rye, and millet which are either not attractive to honey bees or primarily wind pollinated. Fruiting vegetables (except okra) are largely unattractive to honey bees.	**Definite Risks to Bees**	**Seed Coatings** ■ Samson-Robert, et al. (2015) find that neonicotinoid seed coating particles during the planting season can alter bumble bee neuronal activity. ■ Douglas, et al. (2014) conclude that neonic seed coatings can lead to damaging pest outbreaks by killing off natural pest predators that would otherwise keep certain pest populations under control. **On-Field** ■ Alburaki, et al. (2015) observe elevated acetylcholinesterase (AChE) activity among honey bees that collected corn pollen from treated field, which can induce physiological stress and increase pathogen loads. ■ Stanley, et al. (2015) show that neonics impair pollination services; the apple trees visited by bees exposed to neonicotinoids produced apples with fewer seeds—leading to lower overall yields. ■ Hladik, et al. (2015) found neonicotinoid residues frequently in 70 percent of the native bees tested foraging on or near U.S. farmland. ■ Stanley and Raine (2016) report that very low levels neonicotinoid affects the foraging behavior of bumble bees, changing their floral preferences, hindering their ability to learn and extract nectar and pollen. **Off-Field Impacts** ■ Schaafsma, et al. (2015) report that neonicotinoids move off-target by wind erosion of contaminated soil from neonicotinoid-treated fields. ■ Samson-Robert, et al. (2014) find that water samples collected from corn fields were contaminated with at least one neonicotinoid compound, although most contained more than one.
Risks Concerns Exists with Uncertainties in Assessment	Residue data unavailable[a]: legumes, tree nuts, and certain application methods of stone fruits, berries/small fruits, oilseed, herbs and spices, pome fruits.* Limitations in available studies[b]: cucurbit vegetables, citrus fruits, and berries/small fruits.		
Definite Risks to Bees	Citrus fruits (foliar). Cotton (foliar, soil & seed treatment applications).		

[a] EPA notes that there is the potential to extrapolate data from other neonicotinoid chemicals for the same use pattern and application method. For some application methods, data are not available and there are no data expected for the other neonicotinoid chemicals.

[b] Available residue studies create uncertainty in the risk determinations.

**Residue data for imidacloprid are expected in 2016.*

Pollinators continue to be threatened by neonicotinoids

Recently published studies continue to confirm neonicotinoids' harmful effect on bees and other pollinators, as well as their widespread presence in the environment. Pollinators are not only exposed via pollen and nectar from treated crops or soil, but also from natural vegetation and surface water that have become contaminated as a result of pervasive use. Sánchez-Bayo et al. (2016) note that bees are threatened not only from insecticides like neonicotinoids that are highly toxic to bees, but also from herbicides that reduce their food resources, indirectly affecting survival and reproduction. According to David et al. (2016) and Botías et al. (2015), even wildflower pollen is contaminated with a wide range of pesticides, including neonicotinoids, indicating that exposures are higher and more prolonged than currently recognized.

Neonicotinoids have been linked to impairments in bee foraging, learning ability, growth and reproduction, and overall decline in colony health. Imidacloprid, in particular, has been linked to decreases to the olfactory learning ability of adults, and damages the development of the nervous system in regions responsible for both olfaction and vision during the larval stage (Peng, et al., 2016). In fact, one study, *Neonicotinoid pesticides severely affect honey bee queens* (Williams et al., 2015) observe that exposure to field-realistic concentrations of neonicotinoids during development can severely affect queens of honey bees in adulthood.

These impacts are also observed in wild bees. Bumble bee colonies exposed to imidacloprid were observed to have deficits in colony growth and nest condition, with the pesticide found accumulating in their brains three days after exposure, resulting in neuronal impairment. Feltham et al. (2014), in their study, find that near infinitesimal exposure to neonicotinoids reduces bumble bees' ability to gather food by 57%, demonstrating that field-realistic concentrations of these pesticides substantially impact foraging ability of these bees, and reduces queen production in exposed colonies.

Immune suppression in bees is another phenomena observed after bee exposure to neonicotinoids. This opens the way to parasite infections and viral diseases that are spread among individuals and bee colonies. A study by Brandt et al. (2016) finds that the neonicotinoids imidacloprid, clothianidin and thiacloprid affect the individual immunocompetence of honey bees, possibly leading to an impaired disease resistance capacity at sublethal levels.

A team of scientists led by Dave Goulson, Ph.D. (2015) puts into perspective the state of bee health in relation to the numerous pressures they face in the modern world: chronic exposure to multiple interacting stressors, including pesticide exposure and reduced immune response, is driving honey bee colony losses and declines of wild pollinators. The scientists suggest taking steps to reduce stress on bees, incorporating flower-rich habitat into farmland, and reducing pesticide use through the adoption of more sustainable farming methods.

Adverse Effect level or LOAEC) at which effects were observed was 50 ppb. Honey bees consuming contaminated nectar had reduced numbers of pupae, adult workers, and pollen and honey stores. For long-term exposures, young, larval bees were determined to be less sensitive to the effects of imidacloprid than adult honey bees.

> ***Note:*** *When compared to pollen, EPA determined that exposure to contaminated nectar is a more significant route of exposure for bees and their colonies. This is important as nectar is the primary source of food for adult workers and drone bees.*

2. There Are Many Routes of Exposure, but EPA Is Not Quantifying Them All

For its assessment, EPA primarily recognizes bees' direct exposure to foliar sprays, including drift, and oral ingestion, e.g., consumption of contaminated pollen and nectar as a result of various imidacloprid applications. The agency does also acknowledge that bees experience many other exposure pathways, including contaminated surface water, plant guttation fluids, honey dew, soil (for ground-nesting bees), and leaves. However, EPA explains that it "lacks information to understand the relative importance of these other routes of exposure and/or to quantify risks from these other routes." Unfortunately, bees' risks to these other routes of exposure are critical to a comprehensive hazard assessment. In fact, neonics have been detected in water puddles on treated fields at levels as high as 63 ppb –levels that can "elicit a wide array of sublethal effects in individuals and colony."[1]

> ***Note:*** *In this assessment, EPA does not include exposures from ornamental/garden plants and their potential hazards to bees. These are expected to be addressed later this year.*

3. Limited Data on Wild Bees Keeps Them at Risk

Wild and native bees, like bumble bees and solitary bees, differ from honey bees in their exposure patterns and sensitivity to imidacloprid. For instance, bumble bee colonies are adversely affected by imidacloprid at levels "considerably lower than those observed for the honey bee." A study by Cresswell et al. (2012) in the journal *Zoology* also finds that bumble bees experience a more deleterious effect when exposed to imidacloprid-contaminated nectar compared to honey bees.[2] EPA has very limited data for wild bees, and thus uncertainties remain in extrapolating data from honey bees. However, EPA believes that the honey bee assessment can be used to bridge the gap to the other bee species, despite these biological differences.

1. *Samson-Robert O, Labrie G, Chagnon M, Fournier V. 2014. Neonicotinoid-contaminated puddles of water represent a risk of intoxication for honey bees. PLoS One. 9(12):e108443.*
2. *Cresswell JE, Page CJ, Uygun MB, et al. 2012. Differential sensitivity of honey bees and bumble bees to a dietary insecticide (imidacloprid). Zoology (Jena). 115(6):365-71.*

Imidacloprid Spray Drift Endangers Bees. What About Dust Drift from Coated Seeds?

According to EPA's assessment, off-field spray drift poses risks regardless of the treated crop's attractiveness to bees, or the type of agronomic practices on the treated field. For all foliar spraying, drift exposure may occur on the treated field, adjacent land, and surrounding areas. EPA utilized the spray drift model AgDRIFT to evaluate various drift scenarios and estimates the potential for off-field risks. Unsurprisingly, the most egregious spray drift risks come from aerial applications, where risks are expected at distances more than 1000 ft. from treated fields.

Contaminated dust that results from machine planting of coated seeds, while acknowledged as an exposure pathway, was not addressed in this assessment. This contaminated dust can lead to residues on nearby plants, soil and surface water, resulting in bee exposures. The amount of dust ejected into the air is determined by the type of seed coating, the planting equipment and lubrication agents, along with environmental factors like wind speed and humidity. EPA simply states that it is working with stakeholders on developing best management practices to limit the dust.

4. Real-World Data Finds Imidacloprid Contamination Low Level but Pervasive

According to EPA, pollen samples from corn and sunflower fields where sown seed was treated with imidacloprid contain residues that are detected frequently (ranging from 36 – 58% detection). While the average concentrations detected ranged from 0.6 – 3.0 ppb, which are considered low and just above the limit of detection for these studies, EPA points out (without identifying a hazard) that, "Despite widespread use of imidacloprid on crops through multiple application methods, the magnitude and frequency of detection in hive matrices is relatively low." But, according to Feltham et al. (2014), even at extremely low levels, imidacloprid (0.7ppb) can impact bees' foraging.[3] Similarly, other studies have found that at concentrations between 1ppb and 10ppb imidacloprid can impair the neurological systems of bees and the survival of the colony.[4,5]

Photo by Layla Brooks Maida, Vale, London.

> ***Note:*** Hive monitoring studies across the U.S. and Europe also found similar trends, in that when imidacloprid was frequently detected, the levels were very low.

5. Treated Crops Endanger Foraging Bees

For crops that can be treated with imidacloprid, EPA identifies the applications that pose risks to bees. According to EPA, applications to citrus fruits (foliar) and cotton pose definite risks to bees, while leafy greens, soil treatment to blueberries, and fruits/vegetables that are not attractive to bees are considered low risk.

EPA's assessment relies on whether crops are attractive to bees, wind pollinated, or harvested before bloom as determinants in establishing the extent of the associated exposure risks. However, it should be noted that due to the systemic nature of the insecticide, residues can and do remain in and on plant material, soil, and even water for long periods of time, creating continuous exposure patterns and risks which cannot be dismissed or ignored.

What Is Needed from the Future Neonic Reviews in 2016?

EPA announced that the pollinator risk assessments for neonicotinoids (clothianidin, thiamethoxam, and dinotefuran) will be released in December 2016. Based on the assessment for imidacloprid, the expectation is that these future assessments may also be limited in scope and data, ignoring the full range of use patterns, exposed wildlife, and exposure pathways.

In its upcoming ecological assessments of neonicotinoids, EPA must address the following (some of which it has identified):

- Wildlife effects to birds, fish, aquatic organisms, and others.
- Uses on ornamentals, turf, forestry, and other residential and non-agricultural sites.
- Registered crop uses.
- Vulnerable wild bees and other insect pollinators.
- All routes of wildlife exposure, including soil and water contamination, for all neonics.
- Data gaps and uncertainties that leave future assessments incomplete and unacceptable for any crops and exposure routes.
- Indiscriminate ecological poisoning of these systemic pesticides, raising the need to consider suspending or cancelling registrations.

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4. *Feltham, H, Park, K, Goulson, D. 2014. Field realistic doses of pesticide imidacloprid reduce bumblebee pollen foraging efficiency. Ecotoxicology. 23(3) pp 317-323.*
5. *Peng, YC and Yang, EC. 2016. Sublethal Dosage of Imidacloprid Reduces the Microglomerular Density of Honey Bee Mushroom Bodies. Sci Rep. 6: 19298.*
6. *Yang E. C., Chang H. C., Wu W. Y. & Chen Y. W. 2012. Impaired olfactory associative behavior of honeybee workers due to contamination of imidacloprid in the larval stage. PLoS One 7, e49472.*