July 29th, 2013

Studies Concluding Neonicotinoids Are Lethal To Bees

1) **Multiple Routes of Pesticide Exposure for Honey Bees Living Near Agricultural Fields.** Christian H. Krupke *et al* (2012). Plos One. http://bit.ly/y18DNh

Abstract

Populations of honey bees and other pollinators have declined worldwide in recent years. A variety of stressors have been implicated as potential causes, including agricultural pesticides. Neonicotinoid insecticides, which are widely used and highly toxic to honey bees, have been found in previous analyses of honey bee pollen and comb material. However, the routes of exposure have remained largely undefined. We used LC/MS-MS to analyze samples of honey bees, pollen stored in the hive and several potential exposure routes associated with plantings of neonicotinoid treated maize. Our results demonstrate that bees are exposed to these compounds and several other agricultural pesticides in several ways throughout the foraging period. During spring, extremely high levels of clothianidin and thiamethoxam were found in planter exhaust material produced during the planting of treated maize seed. We also found neonicotinoids in the soil of each field we sampled, including unplanted fields. Plants visited by foraging bees (dandelions) growing near these fields were found to contain neonicotinoids as well. This indicates deposition of neonicotinoids on the flowers, uptake by the root system, or both. Dead bees collected near hive entrances during the spring sampling period were found to contain clothianidin as well, although whether exposure was oral (consuming pollen) or by contact (soil/planter dust) is unclear. We also detected the insecticide clothianidin in pollen collected by bees and stored in the hive. When maize plants in our field reached anthesis, maize pollen from treated seed was found to contain clothianidin and other pesticides; and honey bees in our study readily collected maize pollen. These findings clarify some of the mechanisms by which honey bees may be exposed to agricultural pesticides throughout the growing season. These results have implications for a wide range of large-scale annual cropping systems that utilize neonicotinoid seed treatments.

2) ***In situ* replication of honey bee colony collapse disorder.** Chensheng LU *et al* (2012). Bulletin of Insectology. http://hvrd.me/YOQ3CT

Abstract

The concern of persistent loss of honey bee (*Apis mellifera* L.) colonies worldwide since 2006, a phenomenon referred to as colony collapse disorder (CCD), has led us to investigate the role of imidacloprid, one of the neonicotinoid insecticides, in the emergence of CCD. CCD is commonly characterized by the sudden disappearance of honey bees (specifically worker bees) from hives containing adequate food and various stages of brood in abandoned colonies that are not

occupied by honey bees from other colonies. This *in situ* study was designed to replicate CCD based on a plausible mechanistic hypothesis in which the occurrence of CCD since 2006 was resulted from the presence of imidacloprid, one of the neonicotinoid insecticides, in high-fructose corn syrup (HFCS), fed to honey bees as an alternative to sucrose-based food. We used a replicated split-plot design consisting of 4 independent apiary sites. Each apiary consisted of 4 different imidacloprid-treated hives and a control hive. The dosages used in this study were determined to reflect imidacloprid residue levels reported in the environment previously. All hives had no diseases of symptoms of parasitism during the 13-week dosing regime, and were alive 12 weeks afterward. However, 15 of 16 imidacloprid treated hives (94%) were dead across 4 apiaries 23 weeks post imidacloprid dosing. Dead hives were remarkably empty except for stores of food and some pollen left, a resemblance of CCD. Data from this *in situ* study provide convincing evidence that exposure to sub-lethal levels of imidacloprid in HFCS causes honey bees to exhibit symptoms consistent to CCD 23 weeks post Imidacloprid dosing. The survival of the control hives managed alongside with the pesticide-treated hives unequivocally augments this conclusion. The observed delayed mortality in honey bees caused by imidacloprid in HFCS is a novel and plausible mechanism for CCD, and should be validated in future studies.

3) **ImmuneSuppression by Neonicotinoid Insecticides at the Root of Global Wildlife Declines.** Rosemary Mason *et al* (2012). Journal of Environmental Immunology and Toxicology. http://bit.ly/13I2JAf

Summary

Outbreaks of infectious diseases in honey bees, fish, amphibians, bats and birds in the past two decades have coincided with the increasing use of systemic insecticides, notably the neonicotinoids and fipronil. A link between insecticides and such diseases is hypothesised. Firstly, the disease outbreaks started in countries and regions where systemic insecticides were used for the first time, and later they spread to other countries. Secondly, recent evidence of immune suppression in bees and fish caused by neonicotinoids has provided an important clue to understand the sub-lethal impact of these insecticides not only on these organisms, but probably on other wildlife affected by emerging infectious diseases. While this is occurring, environmental authorities in developed countries ignore the calls of apiarists (who are most affected) and do not target neonicotinoids in their regular monitoring schedules. Equally, scientists looking for answers to the problem are unaware of the new threat that systemic insecticides have introduced in terrestrial and aquatic ecosystems.

4) **Seed-dressing systemic insecticides and honeybees.** Laura Maxim and Jeroen van der Sluijs (2012). European Environment Agency. http://bit.ly/1bRwNid

In 1994 French beekeepers began to report alarming signs. During summer, many honeybees did not return to the hives. Honeybees gathered close together in small groups on the ground or hovered, disoriented, in front of the hive and displayed abnormal foraging behaviour. These signs were accompanied by winter losses. Evidence pointed to Bayer's seed-dressing systemic insecticide Gaucho®, which contains the active substance imidacloprid. This chapter presents the historical evolution of evidence on the risks of Gaucho® to honeybees in sunflower and maize seed-dressing in France, and analyses the actions in response to the accumulating evidence regarding these risks. The social processes that ultimately lead to application of the precautionary principle for the ban of Gaucho® in sunflower and maize seed-dressing are described, with a focus on the ways in which scientific findings were used by stakeholders and decision-makers to influence policy during the controversy. Public scientists were in a difficult position in this case. The results of their work were central to a social debate with high economic and political stakes. In certain cases their work was not judged according to its scientific merit but based on whether or not it supported the positions of some stakeholders. This situation tested the ability and courage of researchers to withstand pressure and continue working on imidacloprid. Other European countries also suspended neonicotinoid seed-dressing insecticides. Evidence of the toxicity of neonicotinoids present in the dust emitted during sowing of coated seeds supported such decisions. Most important, the French case highlighted the major weaknesses of regulatory risk assessment and marketing authorisation of pesticides, and particularly neonicotinoids. These insights were recently confirmed by work by the European Food Safety Authority. From this case study eight lessons are drawn about governance of controversies related to chemical risks. The study is followed by two additional texts. A first panel presents Bayer Crop Science's comments on the analysis in this chapter. A second contains the authors' response to the Bayer comments.

5) **The Science, Law and Policy of Neonicotinoids and Bees: A New Test Case for the Precautionary Principle.** Alberto Alemanno (2013). European Journal of Risk Regulation. http://bit.ly/1byS7EM

Abstract

Once more, while facing an analogous risk phenomenon affecting their predominantly homogeneous societal and economic interests, the two sides of the Atlantic seem to adopt diverging stances. Amid the publication of several new studies and a set of EFSA scientific opinions linking the use of the world's most widely used pesticides to bee decline, the European Union adopted a temporary ban on their use. While the Commission does not Expressly rely on it, its restrictive decision is clearly based on the controversial precautionary principle. Yet, as it is discussed in this article, the conformity of this decision with the requirements that determine the legal invocation of this principle remains doubtful.

This article proceeds as follow. Part II first introduces the reader to the main features and usages of these controversial insecticides, called neonicotinoids. It then discusses how concerns have arisen around their use and analyses the available science exploring their impact on the sudden decline of bee colonies. Part III identifies and comments the restrictive actions currently undertaken across the European Union both at the national and EU level. Part IV in turn provides an overview of the scientific and regulatory approaches adopted by US authorities vis-à-vis neonicotinoids. By building upon the previous two sections, Part V contrasts the EU scientific and regulatory approach towards the use of these pesticides with

that adopted by the US authorities. It then attempts at illustrating the factors explaining the current regulatory divergence across the Atlantic upon the issue of neonicotinoids. In order to provide a legal analysis of the EU restrictive stance over these pesticides, Part VI measures how the EU controversial restrictive measures score under both EU and WTO law. Lastly, some final conclusions provide some recommendations on how to render less controversial the invocation of the precautionary principle in the EU and beyond.

6) **New fears over bee declines.** Michael Gross (2011). Current Biology. http://bit.ly/1677BAi

Excerpt from Text

An additional problem, according to Tennekes, is that the pesticides are also used as soil treatment and leach from the soil into the ground water, where they hit non-target insects and the birds that feed on them. The use of the neonicotinoid imidacloprid in the Netherlands increased ten-fold from 1995 to 2004, when over 6,000 kg of the chemical was applied to over 40,000 hectares. Since 2004, the Dutch Water Boards have reported significant contaminations of ground water with this neonicotinoid. “The excessive imidacloprid levels noted in surface water of western Dutch provinces with intensive agriculture have already been associated with insect decline and a dramatic decline of common grassland birds,” Tennekes writes in his book.

7) **Lethal aerial powdering of honey bees with neonicotinoids from fragments of maize seed coat.** Matteo Marzaro *et al* (2011). Bulletin of Insectology. http://bit.ly/13AJCIL

Abstract

Losses of bees have been reported in Italy concurrent with the sowing of maize coated with neonicotinoids where pneumatic drilling machine were used. Solid particles with systemic insecticide, falling on the vegetation surrounding the sown area, were thought to poison bees foraging on contaminated nectar and pollen. However, bees fed with guttation drops and dew collected from the surrounding vegetation of sown fields showed no acute toxicity. Chemical analysis showed a relatively low content of neonicotinoid in dew and guttation. Thus, the acute poisoning of bees linked to the vegetation contaminated by seed coated fragments containing neonicotinoids was again unproven. For this reason the direct aerial powdering of bees was investigated exposing caged bees around the sown area, not in contact with vegetation. High or low toxicity emerged in different trials. The synergistic effect on bees of high humidity on toxicity of powder containing neonicotinoid was hypothesized. A clear indication that bees were killed by powdering, only if held in high humidity, emerged. Chemical analysis showed high quantities of neonicotinoid insecticide in dead bees earlier exposed to dust in the field.

8) Pesticides linked to bee deaths. Michael Gross (2008). Current Biology
http://bit.ly/19fThbK

Excerpt from Abstract

In May, the Federal Office of Consumer Protection and Food Safety (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit, BVL) withdrew the licences for all clothianidin products. In a recent official statement, the authority identifies batches of maize seed as the bee killers. Investigations suggest that the clothianidin had not been bound strongly enough to the seeds, resulting in fine powders rich in the insecticide. When farmers used these faulty batches in a certain kind of sowing equipment that tends to disperse such powders in the air, the toxin ended up on flowers where it affected bees.

9) Review: An overview of the environmental risks posed by neonicotinoid insecticides. Dave Goulson (2013). Journal of Applied Ecology. http://bit.ly/1bFptBZ

Summary

Neonicotinoids are now the most widely used insecticides in the world. They act systemically, travelling through plant tissues and protecting all parts of the crop, and are widely applied as seed dressings. As neurotoxins with high toxicity to most arthropods, they provide effective pest control and have numerous uses in arable farming and horticulture. However, the prophylactic use of broad-spectrum pesticides goes against the long-established principles of integrated pest management (IPM), leading to environmental concerns. It has recently emerged that neonicotinoids can persist and accumulate in soils. They are water soluble and prone to leaching into waterways. Being systemic, they are found in nectar and pollen of treated crops. Reported levels in soils, waterways, field margin plants and floral resources overlap substantially with concentrations that are sufficient to control pests in crops, and commonly exceed the LC_{50} (the concentration which kills 50% of individuals) for beneficial organisms. Concentrations in nectar and pollen in crops are sufficient to impact substantially on colony reproduction in bumblebees. Although vertebrates are less susceptible than arthropods, consumption of small numbers of dressed seeds offers a route to direct mortality in birds and mammals. *Synthesis and applications*. Major knowledge gaps remain, but current use of neonicotinoids is likely to be impacting on a broad range of non-target taxa including pollinators and soil and aquatic invertebrates and hence threatens a range of ecosystem services.

10) Fatal powdering of bees in flight with particulates of neonicotinoids seed coating and humidity implication. V. Girolam *et al* (2011). http://bit.ly/14Dypcl

Abstract

Losses of honeybees have been reported in Italy concurrent with the sowing of corn coated with neonicotinoids using a pneumatic drilling machine. Being unconvinced that solid particles containing systemic insecticide, falling on the vegetation surrounding the sown area, could poison bees foraging on contaminated nectar and pollen, the effect of direct aerial powdering was tested on foragers in free flight near the drilling machine. Bees were conditioned to visit a dispenser of sugar solution whilst a drilling machine was sowing corn along the flight path. Samples of bees were captured on the dispenser, caged and held in the laboratory. Chemical analysis showed some hundred nanograms of insecticide per bee. Nevertheless, caged bees, previously contaminated in flight, died only if kept in conditions of high humidity. After the sowing, an increase in bee mortality in front of the hives was also observed. Spring bee losses, which corresponded with the sowing of corn-coated seed, seemed to be related to the casual encountering of drilling machine during foraging flight across the ploughed fields.

11) Crop Pollination Exposes Honey Bees to Pesticides Which Alters Their Susceptibility to the Gut Pathogen *Nosema cerana.* Jeffery S. Pettis *et al* (2013). Plos One. http://bit.ly/15L58cv

Excerpt from Text

Our results are consistent with previously published pesticide analyses of pollen collected by honey bees or honey bee nest material. The more intensive and geographically more diverse sampling of Mullin et al. resulted in almost triple the number of pesticides we found, but the average number of pesticides per sample (7.1) is slightly lower than our 9.1. In our study and those listed above, pesticides applied by beekeepers to control hive pests were present in a large proportion of the samples, often in quantities higher than most of the pesticides that are applied to crops.

Our results combined with several recent studies of specific pesticides' effects on *Nosema* infection dynamics indicate that a detrimental interaction occurs when honey bees are exposed to both pesticides and *Nosema*. Specific results vary, and may depend on the pesticide or dose used. For example, bees exposed to imidacloprid and *Nosema* can have lower spore counts than bees only infected with the pathogen but also exhibit hindered immune functioning. Our study improves on previous methodologies by feeding pollen with real-world pesticide blends and levels that truly represents the types of exposure expected with pollination of agricultural crops. The significant increase in *Nosema* infection following exposure to the fungicides in pollen we found therefore indicates a pressing need for further research on lethal and sub-lethal effects of fungicides on bees. Given the diverse routes of exposure to pesticides we show, and increasing evidence that pesticide blends harm bees, there is a pressing need for further research on the mechanisms underlying pesticide-pesticide and pesticide-disease synergistic effects on honey bee health.

12) A potential link among biogenic amines-based pesticides, learning and memory, and colony collapse disorder: A unique hypothesis. Tahira Farooqui (2013) Neurochemistry International. http://bit.ly/13AWpuz

Abstract

Pesticides are substances that have been widely used throughout the world to kill, repel, or control organisms such as certain forms of plants or animals considered as pests. Depending on their type, dose, and persistence in the environment, they can have impact even on non-target species such as beneficial insects (honeybees) in different ways, including reduction in their survival rate and interference with their reproduction process. Honeybee *Apis mellifera* is a major pollinator and has substantial economical and ecological values. Colony collapse disorder (CCD) is a mysterious phenomenon in which adult honeybee workers suddenly abandon from their hives, leaving behind food, brood, and queen. It is lately drawing a lot of attention due to pollination crisis as well as global agriculture and medical demands. If the problem of CCD is economy a big time. Causes of CCD are not known. In this overview, I discuss CCD, biogenic amines-based-pesticides (neonicotinoids and formamidines), and their disruptive effects on biogenic amine signaling causing olfactory dysfunction in honeybees. According to my hypothesis, chronic exposure of biogenic amines-based-pesticides to honeybee foragers in hives and agricultural fields can disrupt neural cholinergic and octopaminergic signaling. Abnormality in biogenic amines-mediated neuronal signaling impairs their olfactory learning and memory, therefore foragers do not return to their hive – a possible cause of CCD. This overview is an attempt to discuss a hypothetical link among biogenic amines-based pesticides, olfactory learning and memory, and CCD.

13) Assessment of the Environmental Exposure of Honeybees to Particulate Matter Containing Neonicotinoid Insecticides Coming from Corn Coated Seeds. Andrea Tapparo (2012). http://bit.ly/Az2VOJ

Abstract
Since seed coating with neonicotinoid insecticides was introduced in the late 1990s, European beekeepers have reported severe colony losses in the period of corn sowing (spring). As a consequence, seed-coating neonicotinoid insecticides that are used worldwide on corn crops have been blamed for honeybee decline. In view of the currently increasing crop production, and also of corn as a renewable energy source, the correct use of these insecticides within sustainable agriculture is a cause of concern. In this paper, a probable—but so far underestimated—route of environmental exposure of honeybees to and intoxication with neonicotinoid insecticides, namely, the atmospheric emission of particulate matter containing

the insecticide by drilling machines, has been quantitatively studied. Using optimized analytical procedures, quantitative measurements of both the emitted particulate and the consequent direct contamination of single bees approaching the drilling machine during the foraging activity have been determined. Experimental results show that the environmental release of particles containing neonicotinoids can produce high exposure levels for bees, with lethal effects compatible with colony losses phenomena observed by beekeepers.

14) The impact of neonicotinoid insecticides on bumblebees, Honey bees and other non-target invertebrates. Vicky Kindemba (2009).The invertebrate Conservation Trust. http://bit.ly/1c0BdSu

Excerpt from Executive Summary

These peer reviewed independent research papers show significant negative impacts of imidacloprid on bees and other non-target invertebrate occur at levels predicted to be present in the UK countryside. These predicted levels are based on Imidacloprid application rates approved for use in the UK. Similar levels have been found present in hives of other countries when EU approved imidacloprid products were used for example Gregorc & Bozic 2004 found five samples of bees out of 12 hives tested in Slovenia were found to contain imidacloprid above 5 µg/kg42 and Chauzat *et al*. 2006 found levels of 5.7 µg/kg in pollen from French hives55.

15) Combined pesticide exposure severely affects individual- and colony-level traits in bees. Richard J. Gill *et al* (2012). Nature**.** http://bit.ly/Y8YtGZ

Abstract

Reported widespread declines of wild and managed insect pollinators have serious consequences for global ecosystem services and agricultural production. Bees contribute approximately 80% of insect pollination, so it is important to understand and mitigate the causes of current declines in bee populations. Recent studies have implicated the role of pesticides in these declines, as exposure to these chemicals has been associated with changes in bee behaviourand reductions in colony queen production. However, the key link between changes in individual behaviour and the consequent impact at the colony level has not been shown. Social bee colonies depend on the collective performance of many individual workers. Thus, although field-level pesticide concentrations can have subtle or sublethal effects at the individual level[8], it is not known whether bee societies can buffer such effects or whether it results in a severe cumulative effect at the colony level. Furthermore, widespread agricultural intensification means that bees are exposed to numerous pesticides when foraging, yet the possible combinatorial effects of pesticide exposure have rarely been investigated. Here we show that chronic exposure of bumblebees to two pesticides (neonicotinoid and pyrethroid) at concentrations that could approximate field-level exposure impairs natural foraging behaviour and increases worker mortality leading to significant reductions in brood development and colony success. We found that worker foraging performance, particularly pollen collecting efficiency, was significantly reduced with observed knock-on effects for forager recruitment, worker losses and overall worker productivity. Moreover, we provide evidence that combinatorial exposure to pesticides increases the propensity of colonies to fail.

16) Neonicotinoid Pesticide Reduces Bumble Bee Colony Growth and Queen Production. Penelope R. Whitehorn *et al* (2012). Science. http://bit.ly/16ZqfXN

Abstract

Growing evidence for declines in bee populations has caused great concern because of the valuable ecosystem services they provide. Neonicotinoid insecticides have been implicated in these declines because they occur at trace levels in the nectar and pollen of crop plants. We exposed colonies of the bumble bee *Bombus terrestris* in the laboratory to field-realistic levels of the neonicotinoid imidacloprid, then allowed them to develop naturally under field conditions. Treated colonies had a significantly reduced growth rate and suffered an 85% reduction in production of new queens compared with control colonies. Given the scale of use of neonicotinoids, we suggest that they may be having a considerable negative impact on wild bumble bee populations across the developed world.

17) A Common Pesticide Decreases Foraging Success and Survival in Honey Bees. Mickael Henry *et al* (2012). Science. http://bit.ly/15Ill14

Abstract

Nonlethal exposure of honey bees to thiamethoxam (neonicotinoid systemic pesticide) causes high mortality due to homing failure at levels that could put a colony at risk of collapse. Simulated exposure events on free-ranging foragers labeled with a radio-frequency identification tag suggest that homing is impaired by thiamethoxam intoxication. These experiments offer new insights into the consequences of common neonicotinoid pesticides used worldwide.

18) Pesticides Under Fire For Risks to Pollinators. Eric Stokstad (2013). Science mag. http://bit.ly/145DivS

Excerpt from Text

As use of neonicotinoids has grown, however, researchers have become concerned about their potential to harm birds, earthworms, aquatic insects, and especially bees. They have found traces of clothianidin and other seed-based pesticides in a large fraction of samples of dead honey bees from commercial beekeeping operations. “That’s pretty astonishing” and "suggestive that the pesticides are related to the deaths," says Reed Johnson, an entomologist at Ohio State University's Agricultural Research and Development Center, Wooster. Honey bees and other pollinators can pick up the chemicals by feeding on nectar and pollen, or sipping on drops of liquid, called guttation, exuded by corn and other plants. The compounds are eventually fed to young bees back at the hive.

19) Neonicotinoids, bee disorders and the sustainability of pollinator services. Jeroen P van der Sluijs *et al* (2013). Current Opinion in Environmental Sustainability. http://bit.ly/16NRSbW

Abstract
In less than 20 years, neonicotinoids have become the most widely used class of insecticides with a global market share of more than 25%. For pollinators, this has transformed the agrochemical landscape. These chemicals mimic the acetylcholine neurotransmitter and are highly neurotoxic to insects. Their systemic mode of action inside plants means phloemic and xylemic transport that results in translocation to pollen and nectar. Their wide application, persistence in soil and water and potential for uptake by succeeding crops and wild plants make neonicotinoids bioavailable to pollinators at sublethal concentrations for most of the year. This results in the frequent presence of neonicotinoids in honeybee hives. At field realistic doses, neonicotinoids cause a wide range of adverse sublethal effects in honeybee and bumblebee colonies, affecting colony performance through impairment of foraging success, brood and larval development, memory and learning, damage to the central nervous system, susceptibility to diseases, hive hygiene etc. Neonicotinoids exhibit a toxicity that can be amplified by various other agrochemicals and they synergistically reinforce infectious agents such as *Nosema ceranae* which together can produce colony collapse. The limited available data suggest that they are likely to exhibit similar toxicity to virtually all other wild insect pollinators. The worldwide production of neonicotinoids is still increasing. Therefore a transition to pollinator-friendly alternatives to neonicotinoids is urgently needed for the sake of the sustainability of pollinator ecosystem services.

20) Requiem for the Honeybee. Joe Cummins (2007). Institute of Science in Society. http://bit.ly/8SHvh

Excerpt from text

A team of scientist led by the National Institute of Beekeeping in Bologna, Italy, found that pollen obtained from seeds dressed with imidacloprid contains significant levels of the insecticide, and suggested that the polluted pollen was one of the main causes of honeybee colony collapse. Analysis of maize and sunflower crops originating from seeds dressed with imidacloprid indicated that large amounts of the insecticide will be carried back to honey bee colonies.