The Environmental Risks of Neonicotinoid Pesticides:

a review of the evidence post-2013

Executive Summary

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Foreword by Greenpeace

Pollinators, including honeybees, wild bees and other insects, play a crucial role in our food and agricultural production. Three-quarters of the crops traded on the global market depend on them to some degree. However, these essential insects are in serious trouble. For example, some wild bumblebees have undergone dramatic declines and become regionally or globally extinct. The data available for other pollinators paint a similarly worrisome picture.

This decline is a symptom of a failed industrial agricultural system. A wealth of scientific information shows that, by driving biodiversity loss, destroying foraging habitats and relying on toxic chemicals to control weeds and pests, industrial farming is threatening the future of the insect pollinators it so depends on.

Pollinators are routinely exposed to toxic chemicals such as insecticides, herbicides and fungicides. The full impact of these exposures is still unclear. However, scientific evidence shows that some insecticides in particular have a direct negative effect on pollinators' health, affecting both individual organisms and entire colonies. These include a number of so-called 'neonicotinoids' as well as other insecticides.

Neonicotinoid insecticides were introduced in the mid-1990s as a 'benign' substitute for older, more damaging substances. Their use has increased rapidly, mainly as seed coatings, and so they have become the most widely used class of insecticides globally. However, since the mid-2000s scientists have raised concerns that neonicotinoids may harm non-target organisms, and in particular honeybees and bumblebees.

In response to the increasing body of scientific evidence, the European Union (EU) adopted a partial ban in 2013 of three neonicotinoids (imidacloprid, clothianidin and thiamethoxam), as well as another insecticide, fipronil. The EU restricted a number of uses, which the European Food Safety Authority (EFSA) had confirmed were a threat to bees. However, EFSA also acknowledged that there was insufficient scientific data to assess certain particular uses and impacts on pollinators other than honeybees.

Since then, the scientific community, driven by the concerns of the public and policymakers, has shown an even stronger interest in the factors contributing to the pollinator crisis, including the impact of specific pesticides.

Greenpeace has commissioned one of the leading scientific institutions in this field, the University of Sussex in the United Kingdom, to conduct a major review of all scientific studies published since 2013 that investigate the impacts of neonicotinoid insecticides on pollinators and the wider environment.

The review confirms the risks identified by EFSA in 2013 and demonstrates the emergence of additional risks to pollinators. New research shows in particular that harm to bees arises not only from treated crop plants but also from contaminated wild plants that have not been treated with neonicotinoids. Recent data also demonstrates that neonicotinoids have become ubiquitous in our environment, polluting water, soil and natural vegetation. The evidence indicates that they pose significant risks to many wildlife species other than bees, including butterflies, beetles and aquatic insects, with possible ripple effects up the food chain.

The findings echo recent conclusions by EFSA, which equally confirm earlier findings on the risk to bees and demonstrate further risks.

On the basis of these findings, it would be irresponsible to continue the use of these chemicals. The three neonicotinoids already subject to partial bans, imidacloprid, clothianidin and thiamethoxam, should be banned altogether. All pesticides should be carefully screened for their effects on bees before regulatory decisions are taken to allow their use.

The time has come to acknowledge that the substitution of harmful chemicals with supposedly 'benign' neonicotinoids is not a sustainable solution for insect pest control. Greater efforts need to be directed at developing and applying ecologically sound practices to prevent the occurrence of insect pests in the first place, and to protect crop plants from them once they arise.

Ecological farming that maintains high biodiversity without any application of chemical pesticides or synthetic fertilisers has been shown to enhance the control of weeds, diseases and insect pests, and increase the overall resilience of ecosystems. A move toward ecological farming is the only way to protect pollinators and safeguard their invaluable services for the benefit of all.

By Marco Contiero & Franziska Achterberg

Executive Summary

Science review conducted by:

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Neonicotinoid pesticides were first introduced in the mid-1990s and since then their use has grown rapidly so that they have become the most widely used class of insecticides in the world, with the majority being used as seed coatings. Neonicotinoids are water-soluble, and so a small quantity applied to a seed will dissolve when in contact with water in the soil and be taken up by the roots of the developing plant. Once inside the plant it becomes systemic and is found in vascular tissues and foliage, providing protection against herbivorous insects. This prophylactic use of neonicotinoids has become extremely widespread on a wide range of arable crops across much of the developed world.

However, only approximately 5% of the neonicotinoid active ingredient is taken up by crop plants and most instead disperses into the wider environment. Since the mid-2000s numerous studies have raised concerns that neonicotinoids may be having a negative effect on non-target organisms. In particular, neonicotinoids were associated with mass poisoning events of honeybees and were shown to have serious negative effects on honeybee and bumblebee fitness when consumed. In response to this growing body of evidence, the European Food Safety Authority (EFSA) was commissioned to produce risk assessments for the use of clothianidin, imidacloprid and thiamethoxam and their impact on bees. These risk assessments, published in January 2013, conclude that the use of these compounds on certain flowering crops poses a high risk to bees. On the basis of these findings, the European Union adopted a partial ban on these substances in May 2013 which came into force on 1st December 2013.

The purpose of this review is to collate and summarise scientific evidence published since 2013 that investigates the impact of neonicotinoids on non-target organisms and to bring it into one place to aid informed decision making. Due to international concern over the unintended impacts of neonicotinoids on wildlife, this topic has received a great deal of scientific attention in this three year period. As the restrictions were put in place because of the risk neonicotinoids pose to bees, much of the recent research work has naturally focussed on this group.

Risks to bees

Broadly, the EFSA risk assessments addressed risks of exposure to bees from neonicotinoids through various routes and the direct lethal and sublethal impact of neonicotinoid exposure. New scientific evidence is available in all of these areas, and it is possible to comment on the change in the scientific evidence since 2013 compared to the EFSA reports. This process is not meant to be a formal assessment of the risk posed by neonicotinoids in the manner of that conducted by EFSA. Instead it aims to summarise how the new evidence has changed our understanding of the likely risks to bees; is it lower, similar or greater than the risk perceived in 2013. With reference to the EFSA 2013 risk assessments baseline, advances in each considered area and their impact on the original assessment can be summarised thus:

- Risk of exposure from pollen and nectar of treated flowering crops. The EFSA reports calculated typical exposure from flowering crops treated with neonicotinoids as seed dressings. Considerably more data are now available in this area, with new studies broadly supporting the calculated exposure values. For bees, flowering crops pose a Risk Unchanged to that reported by EFSA 2013.

- Risk from non-flowering crops and cropping stages prior to flowering. Non-flowering crops were considered to pose no risk to bees. No new studies have demonstrated that these non-flowering crops pose a direct risk to bees. They remain a Risk Unchanged.
- Risk of exposure from the drilling of treated seed and subsequent dust drift. Despite modification in seed drilling technology, available studies suggest that dust drift continues to occur, and that dust drift still represents a source of acute exposure and so is best considered a Risk Unchanged.
- Risk of exposure from guttation fluid. Based on available evidence this was considered a low-risk exposure path by EFSA 2013. New data have not changed this position and so it remains a Risk Unchanged.
- Risk of exposure from and uptake of neonicotinoids in non-crop plants. Uptake of neonicotinoids by non-target plants was considered likely to be negligible, though a data gap was identified. Many studies have since been published demonstrating extensive uptake of neonicotinoids and their presence in the pollen, nectar and foliage of wild plants. Bees collecting pollen from neonicotinoid-treated crops can generally be expected to be exposed to the highest neonicotinoid concentrations, but non-trivial quantities of neonicotinoids are also present in pollen and nectar collected from wild plants, and this source of exposure may be much more prolonged than the flowering period of the crop. Exposure from non-target plants clearly represents a Greater Risk.
- Risk of exposure from succeeding crops. A data gap was identified for this issue. Few studies have explicitly investigated this, but this area does represent some level of risk as neonicotinoids are now known to have the potential to persist for years in soil, and can be detected in crops multiple years after the last known application. However, as few data exist this is currently considered a Risk Unchanged.
- Direct lethality of neonicotinoids to adult bees. Additional studies on toxicity to honeybees have supported the values calculated by EFSA. More data have been produced on neonicotinoid toxicity for wild bee species and meta-analyses suggest a broadly similar response. Reference to individual species is important but neonicotinoid lethality should be broadly considered a Risk Unchanged.
- Sublethal effects of neonicotinoids on wild bees. Consideration of sublethal effects by EFSA was limited as there is no agreed testing methodology for the assessment of such effects. A data gap was identified. Exposure to neonicotinoid-treated flowering crops has been shown to have significant negative effects on free flying wild bees under field conditions and some laboratory studies continue to demonstrate negative effects on bee foraging ability and fitness using field-realistic neonicotinoid concentrations. Greater Risk.

Within this context, research produced since 2013 suggest that neonicotinoids pose a similar to greater risk to wild and managed bees, compared to the state of play in 2013. Given that the initial 2013 risk assessment was sufficient to impose a partial ban on the use of neonicotinoids on flowering crops, and given that new evidence either confirms or enhances evidence of risk to bees, it is logical to conclude that the current scientific evidence supports the extension of the moratorium, and that the extension of the partial ban to other uses of neonicotinoids should be considered.

Broader risks to environmental health

In addition to work on bees, our scientific understanding has also been improved in the following areas which were not previously considered by EFSA:

- Non-flowering crops treated with neonicotinoids can pose a risk to non-target organisms through increasing mortality in beneficial predator populations.
- Neonicotinoids can persist in agricultural soils for several years, leading to chronic contamination and, in some instances, accumulation over time.
- Neonicotinoids continue to be found in a wide range of different waterways including ditches, puddles,

Red mason bee

ponds, mountain streams, rivers, temporary wetlands, snowmelt, groundwater and in outflow from water processing plants.

- Reviews of the sensitivity of aquatic organisms to neonicotinoids show that many aquatic insect species are several orders of magnitude more sensitive to these compounds than the traditional model organisms used in regulatory assessments for pesticide use.
- Neonicotinoids have been shown to be present in the pollen, nectar and foliage of non-crop plants adjacent to agricultural fields. This ranges from herbaceous annual weeds to perennial woody vegetation. We would thus expect non-target herbivorous insects and non-bee pollinators inhabiting field margins and hedgerows to be exposed to neonicotinoids. Of particular concern, this includes some plants sown adjacent to agricultural fields specifically for the purposes of pollinator conservation.
- Correlational studies have suggested a negative link between neonicotinoid usage in agricultural areas and population metrics for butterflies, bees and insectivorous birds in three different countries.

Overall, this recent work on neonicotinoids continues to improve our understanding of how these compounds move through and persist in the wider environment. These water soluble compounds are not restricted to agricultural crops, instead permeating most parts of the agricultural environments in which they are used and in some cases reaching further afield via waterways and runoff water. Field-realistic laboratory experiments and field trials continue to demonstrate that traces of residual neonicotinoids can have a mixture of lethal and sublethal effects on a wide range of taxa. Susceptibility varies tremendously between different taxa across many orders of magnitude, with some showing a negative response at parts per billion with others show no such effects at many thousands of parts per billion. Relative to the risk assessments produced in 2013 for clothianidin, imidacloprid and thiamethoxam which focussed on their effects on bees, new research strengthens arguments for the imposition of a moratorium, in particular because it has become evident that they pose significant risks to many non-target organisms, not just bees. Given the improvement in scientific knowledge of how neonicotinoids move into the wider environment from all crop types, a discussion of the risks posed by their use on non-flowering crops and in non-agricultural areas is urgently needed.

State of Play

Neonicotinoid pesticides were first introduced in the 1990s and since then their use has grown rapidly to become the most widely used class of insecticide in the world. This increase in popularity has largely occurred from the early 2000s onwards (Figure 1). This use has largely been driven by the adoption of seed treatments. Neonicotinoids are water-soluble, and so a small quantity applied to a seed will dissolve when in contact with water and be taken up by the roots of the developing plant. Once inside the plant it becomes systemic and is found in vascular tissues and foliage, providing protection against herbivorous insects. This prophylactic use of neonicotinoids has become extremely widespread – for example, between 79-100% of maize hectares in the United States in 2011 were treated with a neonicotinoid seed dressing (Douglas and Tooker 2015).

However, only approximately 5% of the neonicotinoid active ingredient is taken up by crop plants and most instead disperses into the wider environment. In recent years numerous authors have raised concerns about the impact neonicotinoids may have on non-target organisms. Neonicotinoids released in dust abraded by seed drilling machinery were implicated in mass poisonings of honeybees in Germany and Italy (Pistorius et al. 2009; Bortolotti et al. 2009), neonicotinoids were found in agricultural soils (Bonmatin et al. 2005) and also in the pollen and nectar of treated crops (Bonmatin et al. 2007). In 2012, two high profile studies were published that showed exposure to neonicotinoids in pollen and nectar could have serious effects on honeybee navigation and mortality (Henry et al. 2012) and bumblebee colony development and queen production (Whitehorn et al. 2012). In response to the growing body of work the European Food Safety Authority (EFSA), the body with regulatory oversight for agricultural chemicals, was commissioned to produce a risk assessment on the three most widely used agricultural neonicotinoids (clothianidin, imidacloprid and thiamethoxam) and the risk that they posed to bees (EFSA 2013a; 2013b; 2013c). On the basis of the available evidence EFSA recommended a moratorium on the use of neonicotinoids on treated crops which was accepted and implemented by the European Commission at the end of 2013.

This moratorium is due to conclude shortly. One of the specified objectives was to allow further research on the impact of neonicotinoids on bees in order to inform subsequent regulatory decisions. Since 2013, a great number of studies have been published that consider the impact of neonicotinoids on bees and also a wide range of other non-target taxa. Many large reviews of neonicotinoids impacts on non-target organisms have also been published, for example Nuyttens et al. (2013) on neonicotinoid contaminated dust, Godfray et al. (2014; 2015) on the risks neonicotinoids pose to pollinators, Bonmatin et al. (2015) on environmental fate of and exposure to neonicotinoids, Pisa et al. (2015) and Gibbons et al. (2015) on the impacts of neonicotinoids on non-target terrestris organisms and Morrissey et al. (2015) on contamination of aquatic ecosystems with neonicotinoids and their impact on aquatic organisms, to name a few.

The purpose of this review is to consider the scientific evidence published since 2013 that covers the impact of neonicotinoids on wild non-target organisms (therefore excluding the domesticated honeybee) and to bring it together into one place to aid informed decision making. It is not a formal risk assessment, though comparisons will be made with the knowledge base used in the EFSA risk assessments specifically and that which was known in 2013 more generally. The findings will be of interest to those considering the wider impact of neonicotinoid pesticide use when assessing their future use in agricultural environments.

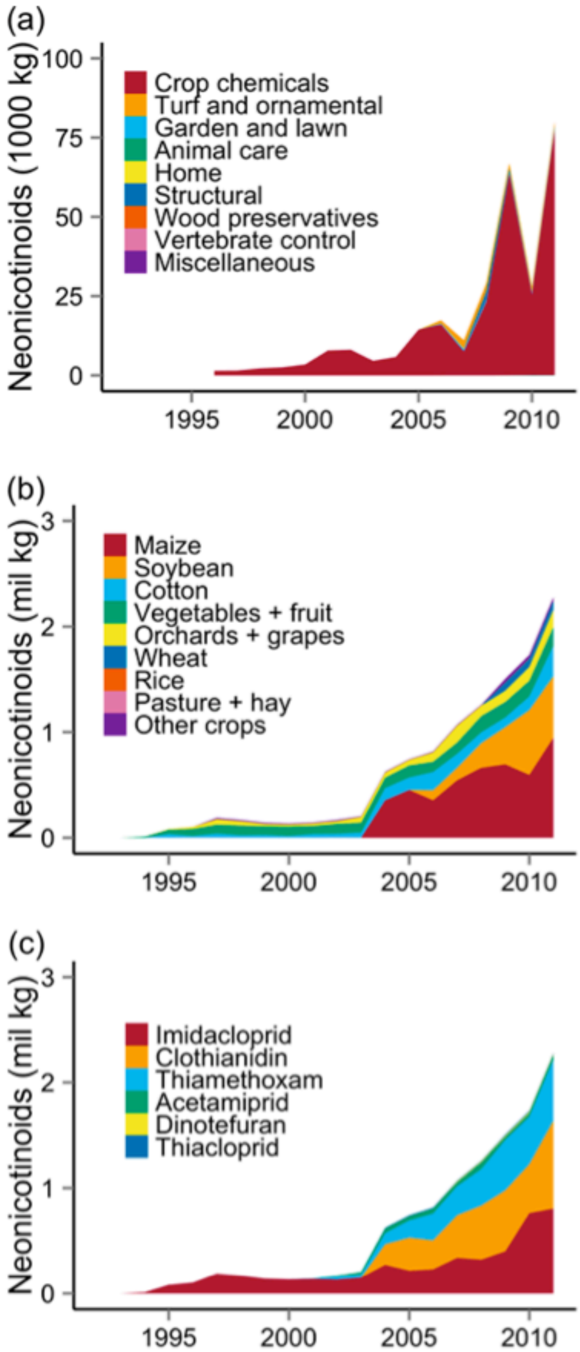

Figure 1. Neonicotinoid sales by (a) product type, (b) use by crop and (c) active ingredient, from 1992 to 2011. Data on use (a) is based on sales data from Minnesota. Data on crops and active ingredients are for the entire U.S., from United States Geological Survey. y-axes represent mass of neonicotinoid active ingredient in thousands or millions of kg. Reproduced from Douglas and Tooker (2015)

Greenpeace is an independent global campaigning organisation that acts to change attitudes and behaviour, to protect and conserve the environment and to promote peace.

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