# Foraging Lines

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## New studies investigating the effect of systemic pesticides in bees generate more questions

RECENT publications on the role of pesticides in bee declines have spurred quite a bit of buzz, so I thought it may be useful to review what we so far know about this highly charged topic.

The United Nations Environment Programme (UNEP) published in 2010 a comprehensive review on the causes and consequences of pollinator decline (Kluser et al., 2010). In their report, which was compiled by an international panel of scientists, they list a number of factors that may be involved in pollinator population instability. This compilation includes habitat degradation/loss of flowers, the invasion of non-native species (e.g., the external parasitic mite *Varroa destructor*), commercial beekeeping habits like the seasonal movement of 2 million bee colonies across the USA, and some agricultural practices, such as the application of systemic pesticides. This last one is probably the most controversial.

According to the National Bee Unit (through the Wildlife Investigation Scheme), there have been no confirmed colony deaths involving the appropriate use of pesticides since 2003. However, herein lies one of the issues, as advocacy groups in favour of banning pesticides say that their detrimental effect must be assessed not just by colony deaths, but by a more subtle, sub-lethal response. Is it possible that even the approved use of pesticides may still be resulting in a negative behavioural/physiological consequence for bees?

It's quite common – and definitely more efficient – for different scientists to divvy up the work on a particular issue. Here at LASI, we do not study pesticides. We are more focused on the loss of forage through land use changes and the challenge of pests and pathogens, both old and new. Healthy or sick, bees still need to eat, and there's no doubt that our landscape looks very different today than it did 100 years ago. So while I've busied myself looking at landscape-scale issues impacting honey bee foraging, I've kept an eye on the other groups that are directly tackling this pesticide issue. Recently, two of these groups have published papers in Science, one of the top-ranking journals, on the sub-lethal effects of pesticides in bees.

At its most basic, a pesticide destroys, repels, or mitigates the effect of a pest (insects, weeds, microbes, fungi, nematodes, etc.) and may be categorised based on a number of characteristics. If we classify pesticides by how or when they work, the most commonly known are the contact pesticides, which are sprayed, for example, over your crops. Alternatively, systemic pesticides are applied to one part of the organism (e.g., the seed), where the pesticide is absorbed, and as the organism grows, the pesticide moves up into other areas, including the nectar and pollen.

In the recent study from the French National Institute for Agricultural Research, researchers fed foragers on a sucrose solution treated with thiamtethoxam, a recently marketed systemic pesticide that is being authorized worldwide to treat oilseed rape, maize, and other crops visited by honey bees (Henry et al., 2012). These treated foragers were accessorized with tiny radio tags, making it easier for the researchers to know when each bee has returned to its hive. Lone bees were then transported to different locations – both familiar and unfamiliar – and released. Those bees that were fed the sucrose + thiamtethoxam were 10-31% less likely to return home successfully compared to their sucrose-only-fed sisters.

Meanwhile, across the Channel, British researchers investigated colony-level effects of pesticides on bumble bees. In their experimental design, *Bombus terrestris* colonies were assigned to one of three treatment groups: control (i.e., no pesticide exposure), "low", and "high" (Whitehorn et al., 2012), which corresponds to no, low (which authors say represents the field-realistic amount) or high (double the low) amounts of imidacloprid, a systemic pesticide. Colonies were fed for 2 weeks on nectar and pollen with no, low, and high amounts of imidacloprid. Then they were placed in a field and left to grow for

6 weeks. At that time, their progress was assessed. Colonies in the low and high treatments weighed 8-12% less compared to the controls. Even more noteworthy was the difference in queen production between the treatments.

Bumble bees have an annual life cycle: each spring, a lone, mated queen emerges to found a new colony. In due time, her daughters (workers) are produced and work to rear more of the queen's daughters. Around mid-summer, the queen will begin to lay males and new queens. These will subsequently mate, and everyone but the newly mated queens will die off as autumn arrives. So queen production is a big deal. Each new queen represents a potential new bumble bee colony. It was found that while colonies in the control group reared an average of 13.7 queens, low treatment colonies reared on average 2 new queens and high treatment colonies reared on average 1.4 new queens. This 85% decline in queen production between control and treated colonies was highly significant.

Of the two studies, I find the one on bumble bees to be most convincing for a few reasons. In the honey bee study, I wonder why Henry et al. chose thiamtethoxam. The authors themselves write that this pesticide is being authorized, from which I gather it is not currently in use. Perhaps their goal was to lend credence against its usage being approved. I wonder if such a study would have been more useful if it had been done on pesticides that are already widely used, which was the route chosen by Whitehorn et al. in their use of imidacloprid (Whitehorn et al., 2012).

Another good aspect of the work on bumble bees is that the authors report experimental results at the colony level. A colony that is 8% leaner may or may not mean anything. However, 85% fewer queens produced in the autumn very clearly means 85% fewer springtime colonies. In contrast, in the honey bee work, the authors conclude by constructing a computer simulation of the population dynamics if in fact 10-31% of foragers fail to return home. In the worst scenarios, the colony populations would fall down to 5,000 bees, which is "the lowest level one can usually observe in current beekeeping practices." Is this actually what they found happened with the experimental colonies? Did they even look at this? Is it even possible to check this? I don't know, and it feels strange to me that this issue is not even addressed. Lastly, a big part of the applicability of this work is in the demonstration that the doses are realistic. And this, it turns out, is a huge point of controversy.

In the bumble bee study, the researchers use two different treatment levels, which is a good experimental practice. The honey bee study used just one level, and that dose is merely said to be a "field-realistic, sub-lethal dose of thiamtethoxam". Both methodologies are falling under criticism. Representatives from the companies that produce the pesticides argue that the quantities used are orders of magnitude higher than what is found in the field. Some scientists disagree; some scientists agree. In general, there is a dearth of field data on actual pesticide levels in pollen and nectar and wax comb. Where there are data, there is no consensus. I'm not an organic chemist, but is it so very difficult to test pesticide residues in bee products?

Clearly more work needs to be done. Many seed-coating pesticides degrade in soil, long before the plant begins to bloom. To begin, I would want to know the ontogeny of these pesticides' presence in the different parts of the plants. Then I would like to see data – from different groups, on different crops, in different places at different times – on the amounts of pesticides found in the nectar and pollen from treated fields. Oilseed rape blooms in the mid/late spring. Maybe this season would be a good time to go out and squeeze a few bees. Sampling their collected nectar would confirm (or not) pesticide presence and quantify their levels (or not). Then these data should be used in any future studies on the lethal and sub-lethal effects of pesticides on bees.

However, despite my reservations, I don't think we can systematically dismiss these findings. The analyses do show an effect of treatment, and the effect is sobering. Maybe we can think of this stage as the waving of a yellow flag. There may be something going on. However, I'm not yet ready to sound a complete and total alarm call.

**References**

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# Neonicotinoids – *our toxic countryside*

SINCE the mid 1990s we have witnessed the catastrophic collapse of millions of honeybee colonies around the world: at least a million colonies died in France, four million in America, three million in Argentina, and hundreds of thousands more in Germany, Italy, Australia and the UK. At the same time, in those same countries, scientists have documented a parallel crash in the populations of frogs, toads, newts, birds and bats – all in relation to arable croplands. Is there a connection between these disparate phenomena? Many beekeepers, and many independent scientists believe the answer is the global use of systemic, neuro-toxic, insecticides: the neonicotinoids. In every case, the collapse of honeybees, bumblebees and other species has been consistent in time and space with the introduction of these hyper-toxic pesticides.

Pesticides used to be applied as a 'reaction' to an attack by a specific crop-pest, such as aphids –which might happen one year in six. But systemic pesticides are now applied 'preventatively' – on hundreds of millions of acres as an 'insurance policy'; the entire landscape, is deliberately made poisonous to <u>all</u> insect life, above and below ground, year after year . The toxins which stay active in the crop until harvest, then

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One of my dead colonies - which dwindled during the winter - having fed on neonic contaminated OSR in the Spring

persist in the soil for years to be absorbed by later crops, or wildflowers, which become equally poisonous to bees and wildlife. Saturating 3,000,000 acres of UK farmland with a deadly insecticide every year is vastly profitable for the companies involved, but it is a disaster for bees, butterflies, bumblebees and farmland birds which have to survive in this near–desert; an ecological dead-zone.

Everyone gets a sore-throat once or twice a year; but would any doctor prescribe you antibiotics 365 days a year, for two decades – because you 'might' get a sore throat? That would be stupid and dangerous; your 'normal' bacteria would soon become resistant to the drug and you could suffer a far more dangerous, possibly fatal infection, for which there was no antibiotic cure. If we tolerate a farming system which permanently poisons our entire farmland eco-system – we are 'sowing dragon's teeth'; calling forth an army of pesticide-resistant insects and plants, which require heavier applications of ever more poisonous toxins to control them. Bees have no future in such a farming system; they will be wiped from the sterilised landscape along with the butterflies, beetles and birds which are vanishing like 'snow off a dyke'. The same military-farming ethos – of attacking Nature with blanket application of noxious herbicides has erased wildflowers from most of our landscape – and the same companies and 'regulators' are responsible for this ecocide.

## THE PESTICIDE HYPOTHESIS – THE TRUTH WHICH DARE NOT SPEAK ITS NAME

Bayer invented Imidacloprid in 1985 and applied for a French license in 1992. They claimed the pesticide was 'harmless to bees' because although it was systemic in the plant, it 'never reached the pollen and nectar' – it was a 'non-issue'. The license was granted and in 1994, the global bee-crisis began, when 400,000 French bee-colonies died after feeding on sunflowers treated with Imidacloprid; Bayer's 'Gaucho'. The cause was self evident: after colonies were placed in the sunflower fields – symptoms of neuro-toxic poisoning appeared within a few days of blooming: bees trembled uncontrollably while foraging on sunflowers; they could not retract their tongues; they fell over and died.

About 30% of the colonies collapsed in a week; other hives simply dwindled and died the next winter. Bayer denied responsibility but said they would do some field studies. The French beekeepers said that the field studies were hopelessly and blatantly rigged.

All of this is recorded in the documentary – 'Temoin Genant' (Embarrassing Witness) – available on Youtube here: http://youtu.be/9boueJGtLPY

It is also covered in Michael Shacker's superb book – *'A Spring Without Bees'*

Despite Bayer's denials, independent tests from Dr Bonmatin at CNRS and Dr Marc Colin at INRA found imidacloprid in both sunflower pollen and nectar, as well as in the dead bees. Bayer then changed its stance – admitting that they had been wrong to say that the pesticide could never emerge in the flowers; they now conceded that it was present but claimed it would only kill bees at levels of 5,000 ppb – which bees could never possibly encounter in the field; this too turned out to be a lie.

Bonmatin's work showed bees were affected at just 3 to 5 ppb and – astonishingly – by chronic exposure at just 0.1ppb – a virtually 'homeopathic' dose.

Bayer then threatened to sue Bonmatin for 'defaming their product' and the French beekeepers spent 3 million Euros between 1994 and 2003 – trying to get justice. They received nothing but denial and opposition from Bayer, from the French Food Safety Agency and from the Toxics Commission run by the French State. Endless science studies were dumped on the table to contradict the independent studies; but all this was just a smokescreen, designed to create 'paralysis by analysis'. The bee-farmers had already proved– to anyone willing to visit the fields, that if bees were placed among treated sunflowers – they began to tremble, to lose co-ordination and die –within days of the blooming. If they were placed in untreated fields – they were fine. If they were placed in chestnut woods – they were fine. If the sunflowers bloomed early – the bees died early; if they bloomed late – they died late. It was so obvious a ten year old could see it; the sunflower fields and the apiaries were ankle deep in dead bees.

Finally, in 2000AD the Minister of Agriculture Mr Glavany, banned Imidacloprid from use on Sunflowers and

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Worker bee bringing home imidacloprid-laced pollen from OSR field

Red Tailed Bumblebee queen on un-contaminated geranium

Oilseed Rape – not because he accepted the science, but because he could not risk 5,000 farmers bringing Paris to a standstill. This did not stop the bee-massacre, because Imidacloprid remained active in the soil for several years – and Fipronil, an even more deadly pesticide was introduced for use on maize.

All of the research papers covering the entire issue are available free of charge here: http://smallbluemarble.org.uk/research/

The French disaster was played out again in other countries, wherever neonicotinoids were introduced. America has lost over 4 million colonies since Clothianidin was licensed in 2006; but the EPA's own scientists strongly advised that it should be refused a licence on the grounds that:

*"Clothianidin is highly toxic to honey bees on an acute contact basis. It has the potential for toxic chronic exposure to honey bees, as well as other nontarget pollinators, through the translocation of clothianidin residues in nectar and pollen. In honey bees, the effects of this toxic chronic exposure may include lethal and/or sub-lethal effects in the larvae and reproductive effects in the queen. . this systemic insecticide is persistent and mobile, stable to hydrolysis, and has potential to leach to ground water, as well as runoff to surface waters."*

Despite this damning report – and the complete lack of any lifecycle studies or chronic toxicity tests – the American EPA granted Clothianidin a 'provisional license' in 2003, as had been given in France. Many believe that this license was granted 'illegally' since the pesticide did not meet the requirements for registration in the USA. Just as in France, this was not a science-based decision, it was politics; the interests of the company, the regulator, the universities and the government were totally united against the beekeepers.

Germany lost tens of thousands of colonies, as did Italy, Slovenia and Switzerland. Here in the UK thousands of beekeepers have lost up to 50% of their hives every winter and some have lost far more. Argentina lost 3 million colonies; Australia has also succumbed, despite the propaganda claims of Croplife that it is unaffected.

## WHAT IS A NEONICOTINOID INSECTICIDE?

Neonics are designed to attack the nerve cells of insects in a similar manner to the way nicotine affects humans. However, when neonicotinoids attack a bee's synapses, they cause irreversible, cumulative damage, according to Dr Henk Tennekes.

Neonicotinoids effectively jam the synapses in the 'on' position, all of the time; the bee's brain is hyper-stimulated, with so much sensory information that the bee just stands there trembling, totally confused and paralysed – like someone with Parkinson's disease. The dose required to produce such neural paralysis is infinitesimally small – just a few parts per billion – and that dose is present in pollen and nectar of most of our arable crops, like oilseed rape, for weeks on end. Recent studies by Cedric Alaux in France and Jeffrey Pettis in the USA have revealed that miniscule doses of neonics weaken the bees' immune system, allowing viruses, bacteria and fungal disease to invade. Neonics are the HIV of the bee-world; the victim appears to die from a range of pathogenic diseases, mites etc, but the real cause is a crippled immune system.

If a bee gathers pollen or nectar containing neonicotinoids it cannot feed or forage properly; with flight and navigation systems wrecked, such bees rarely find the way home. This accounts for the key symptom of so-called CCD: empty hives with few dead bees present. Bees affected sub-lethally by neonicotinoids never find their way home; even if they do make it back to the hive the guard bees will not admit these trembling outcasts. As a result, the hive-population melts away, or never grows large enough to harvest a surplus, or survive the winter.

## HOW ARE NEONICS USED IN THE UK?

Three major nicotinoids are used here in the UK: Clothianidin, Thiamethoxam and Imidacloprid. In 2010 – according to the FERA Pesticide Useage Statistics Website – over 3 million acres of UK crops were treated with neonics. More than 73 tonnes were used; just one microgram of Clothianidin applied to a single maize kernel is enough to kill 200,000 bees; so 73 tonnes is enough to kill hundreds of billions of insects. This is exactly what has happened in the UK in the last 20 years; bees, bumblebees, butterflies and other insects have been wiped from the farming landscape in their trillions. We are witnessing an extinction level event on UK farmland.

## NO ESCAPE

Neonics are used on: oilseed rape, wheat, barley, peas, beans, potatoes, tomatoes and glasshouse crops. They are inescapable: from garden to golf-course, from glass-house to arable prairie – in crops and flowers, soil,

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| Year | Region | Crop Group | Active Substance | Total Area Treated (ha)1 | Total Weight Applied (kg) |
|---|---|---|---|---|---|
| 2010 | Great Britain | All Crops | Clothianidin | 728,209 | 56,216 |
| 2010 | Great Britain | All Crops | Thiamethoxam | 298,007 | 9,105 |
| 2010 | Great Britain | All Crops | Imidacloprid | 187,830 | 8,257 |
| | **TOTALS** | | | **1,214, 046 ha** | **73,578 kg** |
| | | | | or 2,999,907 acres | |

drains, ditches and watercourses.

Neonics are used 'systemically', applied as a coating to the seeds of wheat, barley, oilseed rape, sunflowers, maize, peas, beans, potatoes and hundreds of other crops; in California they were applied to the entire almond crop for the last decade – which is why American bees collapsed so dramatically. They are also used on almost all garden centre plants which we buy, as well as on the bulbs of tulips, lilies, daffodils and crocuses imported from Holland and on vast acreages of domestic lawns, golf courses and school playing fields. The modern garden provides no respite from neonicotinoid poisons. https://secure.fera.defra.gov.uk/pusstats/

**Why Are Neonics So Revolutionary? They are:**

**Hyper-toxic – a dose of just 0.1 parts per billion affects bees**

**Systemic – found throughout the plant in pollen and nectar**

**Actively toxic in the crop for weeks or months –**

**Highly persistent in soil and groundwater for up to 19 years**

**They contaminate wild flowers or follow-on crops for years**

**Used everywhere – 3 million acres of UK crops, 243 million acres in USA**

**Used 'preventatively' year after year,**

## HYPER-TOXIC

Neonics represent a quantum leap in lethality over the older crop pesticides; they are 'hyper-toxic'; IMD is 7,000 times more toxic to bees than DDT.

One teaspoon (5mls) of Imidacloprid mixed with 1000 metric tonnes of water creates a dilution of 5 parts per billion; Dr Bonmatin proved that neonics in sunflower pollen and nectar at levels of just 3 -5 ppb would stop a bee from feeding, flying, grooming or finding its way home. But a far lower dose, just 0.1ppb – fifty times less – produces chronic changes in bee-behaviour, affecting entire colonies. Apart from nerve gases or plutonium, these are the most deadly poisons ever created by the perversion of science.

In 1998 Dr Luc Belzunces fed bees minutes doses of Imidacloprid in sugar syrup and found that it was lethal to 50% of the bees (LD50) at just 40 parts per billion; all of the bees died within 48 hours at this dosage. However, and this is vitally important, he found that if he gave them a dose one-thousand-times smaller, just 40 pico-grammes – the bees all died within ten days. This latter dose is infinitesimal; bees are gathering pollen and nectar contaminated with levels thousands of times higher than this dose. This is the strongest clue as to how chronic, sub lethal poisoning takes place – but of course, no life cycles studies were ever completed in Europe or America.

When the poison-coated seed sprouts, the toxin is absorbed by the roots into the structure of the entire plant: sap, leaves, flower, pollen, nectar and the eventual fruit or grain. The entire plant becomes hyper-toxic to all insect life, both above and below ground; the target species are usually aphids or pollen beetles, but the pollen and nectar are lethal for bees, bumblebees, butterflies and all pollinating insects. In addition, most soil life below the ground is poisoned: earthworms in particular, but all beetles, bugs and larvae are wiped from the field, the garden, the lawn and the golf-course.

This explains why bird populations on farmland in the UK have crashed by up to 80% in the last 20 years: if there are no insects or larvae there will be few insectivorous birds. We are saying a long-goodbye to: the skylark and starling, partridge and peewit, corn bunting and linnet. Farmers can plant headrows with wildflowers 'til the cows come home, but nothing will stop the slide towards ecological extinction unless neonicotinoids are banned, because the substitute-wildflowers, contaminated by residual neonics in the soil, are equally toxic to insects.

## THE PURDUE STUDY

In 2012 Dr Christian Krupke of Purdue University published a study on how Clothianidin from the pollen of American corn affected bees by multiple exposure routes: from planting dust, to toxic pollen, to poisonous residues in soil and water. When corn seeds were planted the exhaust dust from the machines blew onto neighbouring fields and wildflowers. The level of Clothianidin in the dust was 700,000 times above the level needed to kill bees.

Identical bee-kills occurred at planting time in Germany, France and Italy – all from the seed-drill exhaust contaminated with neonics. Clothianidin is applied to maize kernels at 1.25 mg per kernel; an amount sufficient to kill 200,000 bees – about 4 hives-worth.

Corn is planted at 5,000 seeds to the acre; applied to 92 million acres of the American crop, some 45 billion nicotinoid-treated maize kernels were planted in 2010. At four dead hives per kernel, they would be capable of killing 180 billion bee colonies. The fact that America has 'only' lost four million colonies since 2006 is remarkable . In 2010 more than 240 million acres of American maize, soya, wheat and cotton were treated with Clothianidin –an area twenty times the

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size of Scotland was made poisonous to bees, butterflies and pollinating insects.

## CONCLUSION

How was all of this allowed to happen? How did the pesticide companies manage to poison most of the world's arable landscapes and kill close to 10 million bee colonies as well as countless myriads of other insects and birds? The answer is their profits buy 'influence'. More than $1 billion a year from Imidacloprid alone – and possibly $20 billion since 1992 – has enabled them, it is believed, to bully, bribe, coerce, co-opt and persuade the governments, regulators and universities of the developed world as well as national beekeeping associations including our own BBKA. Over £10 million has been channelled to 'bee research' in the UK but not a single penny has been allowed to go to research neonicotinoids. However, the bee-establishment's academic friends have received £millions to look at flowers, habitat loss, mites and a dozen other diversionary smoke-screens. Unsurprising when you discover that Peter Campbell of Syngenta sits on the awards-oversight committee of the BBSRC – alongside the BBKA.

From 2000-2010 – the BBKA accepted large wads of cash from Bayer, BASF and Syngenta in return for cynically endorsing their pesticides as 'bee friendly'. During that entire period, the BBKA refused to even consider neonics as a cause of bee deaths, parroting the line given out by DEFRA and the bee-research establishment in our universities. Their attitude has not changed and their 'partnership' with the Crop Protection Association, with DEFRA and with Bayer, is stronger than ever. Many of us who resigned our membership in disgust, or who were banned from the online Forum, believe that the BBKA has been completely co-opted by the pesticide companies. The recent expressions of 'concern' over neonicotinoids – and the calls for yet more research funding – are merely crocodile tears, a smokescreen for 'business as usual. If the BBKA executive is not actively working full time to promote Bayer's interests – it might as well be – since it has vehemently defended the use of neonicotinoids and supported the pesticide companies to the last ditch. 'Truth will out' however, and if Clothianidin use continues to rise in the UK, we will see accelerating ecological collapse – and the disappearance of bees from most of our arable landscape.

Resources:

Temoin Genant – The French Bee Disaster 1994-2003 – now on Youtube

HYPERLINK "http://youtu.be/9boueJGtLPY" http://youtu.be/9boueJGtLPY

All of the research papers are available free of charge here:

HYPERLINK "http://smallbluemarble.org.uk/research/" http://smallbluemarble.org.uk/research/

DEFRA. FERA Pesticide Use Statistics

HYPERLINK "https://secure.fera.defra.gov.uk/pusstats/" https://secure.fera.defra.gov.uk/pusstats/

Dr Henk Tennekes Toxicology Website:

HYPERLINK "http://www.disasterinthemaking.com/"www.disasterinthemaking.com

HYPERLINK "http://www.farmlandbirds.net" www.farmlandbirds.net

Michael Shacker's book 'A Spring Without Bees'