Mini-review

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A beekeeper's perspective on the neonicotinoid ban

Norman L Carreck[a,b*]

Abstract

Bees and agrochemicals have a long history. For example, the first volume of IBRA's journal *Bee World* in 1919 contains mention of poisoning of bees by spraying an orchard with lead arsenate. Bees being insects, it is self-evident that the use of insecticides to control crop pests poses a risk to them. Bee poisoning incidents became a very serious problem in the 1960s and 1970s with spraying of, in particular, oilseed rape with organophosphorus compounds. The introduction of carbamates and then especially synthetic pyrethroids reduced these problems. Data from the Wildlife Incident Investigation Scheme show that in recent years there have been very few poisoning incidents in the United Kingdom that can be attributed to agricultural insecticides. The introduction of neonicotinoid insecticides has, however, been very controversial. Almost as soon as they were introduced in the 1990s, French beekeepers blamed colony losses on imidacloprid used on sunflowers and maize, but restrictions on its use did not lead to a reduction in losses or to a reduction in beekeepers' concerns. Acute pesticide poisoning incidents by neonicotinoids in Germany and Italy in 2008 further sealed their reputation. Despite laboratory evidence showing their harm, field experience remains equivocal, and many commercial beekeepers continue to move their colonies to oilseed rape crops for honey production. The neonicotinoid moratorium has undoubtedly led to the increased use of older insecticides, and the effect of this on bee populations is unknown and unquantified. Many beekeepers are currently confused by the conflicting evidence.

Keywords: bees; neonicotinoids; beekeepers; moratorium

1 INTRODUCTION

The story of pesticides and beekeeping is far from new. In the first volume of the International Bee Research Association's own journal *Bee World*, in 1919, we find mention of honey bees in orchards in Ontario, Canada, being killed by sprays of Paris green (a copper arsenate compound) and lead arsenate.[1] Even at this early date, scientists were divided about whether such compounds were harmful or not. Concern such as this led to studies initiated by the late Dr Colin Butler at Rothamsted Experimental Station in the 1940s, which showed, for example, that new compounds such as DDT were less harmful to bees than the heavy metal compounds employed previously for insect control. This led to the development of the first protocols for the risk assessment of pesticides to bees by Dr John Stevenson and others, funded by the then Ministry of Agriculture, Fisheries and Food[2,3] in the 1960s and 1970s.

It was really in the 1970s, however, that beekeepers in Britain first experienced major problems of pesticide poisoning.[3,4] This accompanied a rapid expansion of the area of oilseed rape (*Brassica napus*) grown. Like any new crop, it was at first assumed to have few pest problems, but difficulty was soon experienced with the suite of specialist *Brassica* pests which reached huge and damaging populations. Uncontrolled spraying with at first organochlorine and then later organophosphorus compounds, especially on flowering rape crops to control the pollen beetle (*Meligethes aeneus*), seed weevil (*Ceutorhynchus assimilis*) and pod midge (*Dasineura brassicae*), caused widespread death of foraging bees and loss of colonies. Beekeeping associations soon set up 'spray liaison' schemes to warn beekeepers of spraying. When informed of spraying in advance, beekeepers were forced to move colonies away, or to shut them in during the day, which often led in itself to damage. A number of successful prosecutions of farmers took place, but widespread losses of colonies regularly occurred, especially in the eastern arable counties of England,[3] and losses in 1978 were catastrophic.

From 1956 onwards, the Wildlife Incident Investigation Scheme had investigated suspected poisoning incidents, and analysed samples of bees supplied by beekeepers and bee inspectors to identify the chemical compounds involved. Changes in farming practice such as not spraying crops in flower and spraying early in the morning or late in the evening, thus avoiding the peak of honey bee foraging in the middle of the day, reduced the severity and occurrence of poisoning incidents. It should be noted, however, that bumblebees tend to forage early in the morning or late in the evening, so this change in practice may have increased the danger to these bees, but in the absence of monitoring, there are no data available.

* *Correspondence to: NL Carreck, International Bee Research Association, Laboratory of Apiculture and Social Insects, School of Life Sciences, University of Sussex, Falmer, Brighton, East Sussex, BN1 9QG, UK.*
E-mail: norman.carreck@sussex.ac.uk

a *International Bee Research Association, Congresbury, Bristol, UK*

b *Laboratory of Apiculture and Social Insects, Department of Biological and Environmental Science, University of Sussex, Falmer, Brighton, UK*

2 IMPROVEMENTS

Real improvements took place with the introduction of the carbamate insecticides such as pirimicarb, sold under the trade name Aphox and marketed as 'bee friendly', and then the introduction of the synthetic pyrethroids. Although demonstrated to be harmful to bees in the laboratory, in the field, synthetic pyrethroids have a repellent effect to bees, so have proved much safer in practice, and the number of bee poisoning incidents fell dramatically from the late 1980s onwards[5,6] (Fig. 1). In fact, no confirmed incident involving honey bees and the approved use of an agricultural pesticide has occurred in the United Kingdom since 2003. The single incident in 2010 involved a beekeeper who had treated his hives with a wood preservative. In recent years the majority of poisoning incidents have involved the misuse of compounds such as bendiocarb for destroying wild honey bee colonies.

I began beekeeping in 1980, and thus Fig. 1 represents my beekeeping career. For much of this period I have been responsible for more than 100 honey bee colonies, all in an agricultural location, and I have never suffered, nor had any suspicion of having suffered, an incident involving poisoning of my bees. I have, however, been lucky, given that when I joined the Technical Committee of the British Beekeepers Association in the early 1990s, poisoning was the main topic of discussion, and clearly had been for many years. Beekeepers who have taken up the craft in recent years are perhaps unaware of what a serious and real problem poisoning has been in the past.

3 NEONICOTINOIDS

This is not of course the end of the story, as in the mid-1990s concern was raised among beekeepers by reports from France about bee losses caused by the newly introduced class of systemic insecticides, the neonicotinoids, in particular the compound imidacloprid marketed as Gaucho®. Beekeepers reported extensive damage to colonies when foraging on imidacloprid-treated sunflowers and maize, but as was pointed out at the time,[7] the damage resembled the effects of the parasitic mite varroa and associated viruses, rather than poisoning. Restrictions on the use of imidacloprid followed, but losses continued. In hindsight, it is clear that much of this damage was indeed caused by varroa and viruses, as mites resistant to the synthetic pyrethroid fluvalinate, which had been used almost exclusively for varroa control for some years, spread to France at exactly this time.[8]

At the European bee research conference held in 2004, however, a paper was presented by Italian researchers[9] drawing attention to the hazard of dust from neonicotinoid seed dressings posing a threat to bees during sowing operations with modern pneumatic seed drills. In Spring 2008, the worst-case scenario actually happened. Heavy losses of bee colonies occurred in Germany and Slovenia, linked to the use of the neonicotinoid compound clothianidin (Poncho®) as a seed dressing on maize. In the Rhine valley, clothianidin was being used as a compulsory seed dressing on maize, to control the serious notifiable pest the western corn rootworm *Diabrotica virgifera*. The seed dressing was applied at a high rate in conjunction with other chemicals, and the necessary binding agent required to make the treatment 'stick' to the seed was omitted. This resulted in dust, which, in combination with pneumatic seed drills and high winds, led to dust blowing onto flowering oilseed rape nearby, on which bees were foraging, causing losses of colonies.[10] The German government swiftly banned the use of all insecticidal seed dressings while the incident was investigated, but this was soon lifted. Attention has since focused on improving the design of seed drills to prevent a recurrence, although similar incidents have occurred in the United States.

In 2012, four key papers were published, suggesting that neonicotinoids also had more subtle harmful effects on bees, at least in the laboratory. Two, by Gill *et al.*[11] and Whitehorn *et al.*,[12] were well-executed studies, but both used unrealistically large doses of insecticide.[5] Lu *et al.*,[13] on the other hand, carried out a poorly designed experiment, the results of which are essentially of no value, yet their paper attracted much publicity. They treated whole honey bee colonies with one of a range of large doses of imidacloprid in sugar syrup for 9 weeks, based on the assumption that high-fructose corn syrup (HFCS) fed to commercial honey bee colonies in the United States was contaminated with imidacloprid. Unsurprisingly, the colonies died. This seems to have been the main aim of the project: to kill colonies so that it could be reported that symptoms similar to 'colony collapse disorder' could be caused by imidacloprid. However, the study used unrealistically high doses, and the symptoms produced in no way resembled those of colony collapse disorder, which is a very precisely defined set of symptoms.[14] The *Independent* newspaper in the United Kingdom (6 April 2012), however, reported this research with the headline 'New pesticide link to sudden decline in bee population: US study says nerve agent causes Colony Collapse Disorder'. A paper published shortly afterwards, by deGrandi-Hoffman *et al.*,[15] which found no evidence that commercial HFCS is in fact contaminated with imidacloprid, received little publicity.

The fourth study, by Henry *et al.*,[16] demonstrated that a large single dose of thiamethoxam administered over a short time affected individual homing ability of honey bees, and from this the authors went on to infer colony mortality using a honey bee colony population model, but again this was a very unrealistic situation.[5] A subsequent paper by Cresswell and Thompson,[17] which suggested that if their model was recalculated with parameter values more appropriate to the season when most pesticide-treated flowering crops are actually in flower, the colonies would not die, went unreported in the media.

4 THE MORATORIUM

Nonetheless, these four papers were pivotal in the decision by the EU to introduce a moratorium on the use of three neonicotinoids on bee-friendly crops from December 2013. Beekeepers must have been very confused by this, as these mainly laboratory-based studies which reported that neonicotinoids are harmful to bees did not tally with their own experience. Oilseed rape, which had been almost exclusively treated with neonicotinoid seed dressing for more than a decade, continued to be prized by beekeepers as a honey crop, without adverse effects on the bees being noted. Indeed, many beekeepers deliberately move their colonies to oilseed rape.[18,19]

As was highlighted by other speakers at the SCI Conference held in September 2016, the moratorium has led to severe problems being experienced by farmers in several parts of the United Kingdom with controlling pests, especially cabbage stem flea beetles (*Psylliodes chrysocephala*) in the autumn. This has led to farmers reverting to autumn sprays of synthetic pyrethroids, which has largely been ineffectual owing to insect resistance and the difficulty of reaching larvae within the plant stem. Just as we lack information about the subtle sublethal effects of neonicotinoids on bees, however, we know little about whether older pesticides have similar effects.[20]

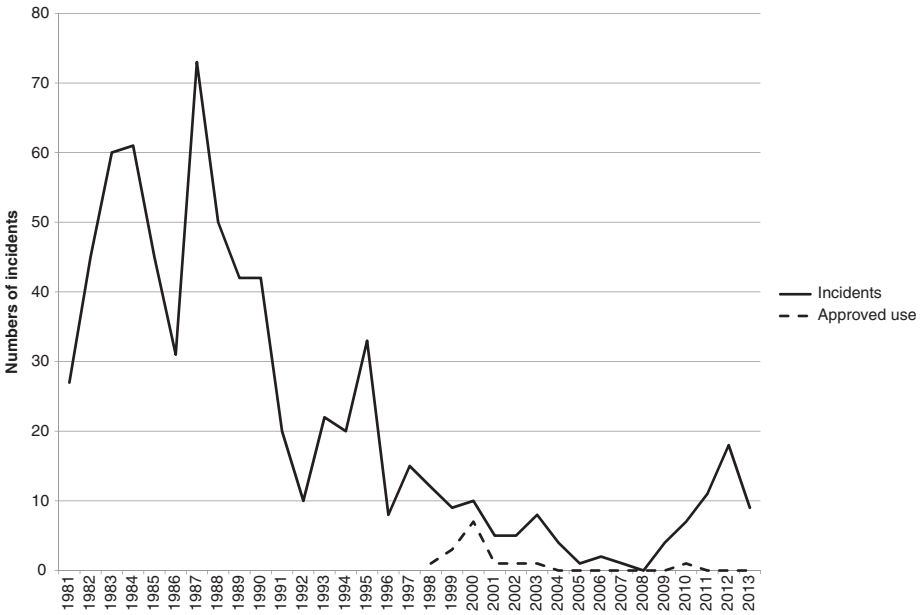

Figure 1. Incidents involving the poisoning of honey bees investigated by the UK Wildlife Incident Investigation Scheme, and those confirmed to have been due to the approved use of a compound. Data from WIIS: http://www.pesticides.gov.uk/guidance/industries/pesticides/topics/reducing-environmental-impact/wildlife (from Carreck and Ratnieks, 2014. © International Bee Research Association. Reproduced with permission of the editors of the *Journal of Apicultural Research*).

It is of course true that bees do not visit oilseed rape in the autumn, and will therefore not be directly affected by these extra sprays, but the situation is more complex than it might appear. These autumn sprays will certainly kill non-target insects, with unknown consequences. One curiosity of the blanket use of neonicotinoid seed dressings in recent years has been that crops have rarely required sprays at flowering in the summer, long after the protective effect of the seed treatment has worn off. It may be that the lack of autumn insecticide sprays has enabled the survival of natural enemies that protect the crop in the summer. The moratorium may therefore also result in increased spraying in the summer, with consequent harmful effects on bumblebees in particular.

The difficulties that farmers have experienced with pest control since the moratorium, together with high input costs and low prices, has already led to a reduction in the area of oilseed rape being grown, and this trend seems set to continue. If this is the case, beekeepers will certainly notice a reduction in this crop, which surveys have consistently shown to be the most important honey crop in the United Kingdom.[18,19] This must inevitably be bad for beekeeping.

5 CONCLUSIONS

In summary, beekeepers have been put in a difficult and very confusing position by the debate about neonicotinoids, with environmental pressure groups on the one hand telling them that neonicotinoids are very harmful, and the agrochemical industry on the other telling them that their products are safe. For those like me who have been keeping bees for more than 30 years, the inescapable conclusion is that the world is much safer for bees with regard to pesticides than in the 1980s, yet this is the exact opposite of the story portrayed in the media. I think that most beekeepers, like the bee science community, are pragmatic, and believe that decline of bee species in diversity and abundance, and increased losses of honey bee colonies, are multicausal.[21,22] It is clear that long-term declines have been due to changes in land use, which mean that there is reduced food for bees and fewer nest sites for wild bees. Weather causes short-term fluctuations, and laid on these factors are many others, of which pesticides are undoubtedly one, but which also include pests and diseases such as the varroa mite.

It is very clear that trust between the various parties has been eroded by this debate, and therefore the introduction of the BeeConnected scheme (www.beeconnected.org.uk), an online system that will enable farmers easily to inform local beekeepers that they are spraying on their crops, is to be welcomed. This is a joint initiative between the British Beekeepers Association, the Crop Protection Association and the National Farmers Union, and may help to restore some of this trust.

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