Researchers confirm that neonicotinoid insecticides impair bee's brains

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Credit: Lilla Frerichs/public domain

Research at the Universities of St Andrews and Dundee has confirmed that levels of neonicotinoid insecticides accepted to exist in agriculture cause both impairment of bumblebees' brain cells and subsequent poor performance by bee colonies.

The contribution of the neonicotinoids to the global decline of insect

pollinators is controversial and contested by many in the agriculture industry. However, the new research, published in the *Journal of the Federation of American Societies for Experimental Biology*, demonstrates for the first time that the low levels found in the nectar and pollen of plants is sufficient to deliver neuroactive levels to their site of action, the bee brain.

Dr Chris Connolly, a Reader in the Division of Neuroscience at Dundee's School of Medicine, has spent several years examining the risk from neonicotinoids and other commonly used classes of pesticides on both honeybees and bumblebees.

He and his colleagues at Dundee carried out combined laboratory and field studies and the data was analysed by Professor Steve Buckland at St Andrews. The results showed very low levels of neonicotinoids caused bumblebee colonies to have an estimated 55 per cent reduction in live bee numbers, a 71 per cent reduction in healthy brood cells, and a 57 per cent reduction in the total bee mass of a nest.

Dr Connolly says the paper represents the best scientific evidence to date connecting neonicotinoid consumption to poor performance of bees and that the effects of the pesticide must be considered by policy makers seeking to protect the abundance and diversity of insect pollinators.

"Our research demonstrates beyond doubt that the level of neonicotinoids generally accepted as the average level present in the wild causes brain dysfunction and colonies to perform poorly when consumed by bumblebees," he said. "In fact, our research showed that the ability to perturb brain cells can be found at 1/5 to 1/10 of the levels that people think are present in the wild.

"This is not surprising as pesticides are designed to affect brains of insects so it is doing what it is supposed to do but on a bumblebee as well

as the pest species. The bumblebees don't die due to exposure to neonicotinoids but their brains cells don't perform well as a result and this causes adverse outcomes for individual bees and colonies.

"This is not proof that neonicotinoids are solely responsible for the decline in insect pollinators, but a clear linear relationship is now established. We can now be confident that at these levels, neonicotinoids disrupt brain function, bee learning and the ability to forage for food and so limit colony growth.

"It may be possible to help bees if more food (bee-friendly plants) were available to bees in the countryside and in our gardens. We suggest that the neonicotinoids are no longer used on any bee-friendly garden plants, or on land that is, or will be, used by crops visited by bees or other insect pollinators."

Insect pollinators provide essential ecosystem services and make an estimated contribution of $215 billion to worldwide economies every year while supporting much of the world's food production. Recent years have seen up to 30 per cent annual honeybee colony losses, while the population of butterflies and other insects is also down and similar declines in insect-pollinated wild plants.

Neonicotinoid contamination of the nectar and pollen consumed by bees is around 2.5 parts per billion (around 1 teaspoon in an Olympic swimming pool). There has been wide debate over whether this level is enough to affect the bees. To answer this question, the Dundee-St Andrews team fed bumblebees this low level of neonicotinoid and measured its accumulation at its target site, the bee brain.

At this level, some neonicotinoids were fast acting, shutting down the major site of energy production, the mitochondria, in brain cells. At even lower levels, brain cells become vulnerable to stimulation by the

normal neurotransmitter used to transmit information. Under these conditions, brain cells cannot function and bees struggle to learn important life skills, such as recognising that the scent of a flower predicts a food reward, or remembering their way home.

To test if these conditions affected whole colonies, the researchers provided nests with 2.5 ppb neonicotinoid in sugar water, while they were free flying in a wilderness environment in the Scottish Highlands, searching for nectar and pollen to raise their brood. They found that bumblebee colonies exposed to the neonicotinoid performed poorly in terms of nest size, number of bees and condition of the nest.

The findings link environmental exposure levels of neonicotinoids to poor bumblebee performance and indicate that decreased brain function is responsible.

Previous field studies conducted by industry had generated inconclusive results, largely because of the small sample size used. This drew criticism from statisticians at St Andrews who maintained that it is possible to produce robust findings from small field studies and performed with Dr Connolly's data.

Steve Buckland, Professor of Statistics at the University of St Andrews, said, "Field studies of the effects of neonicotinoids on bees are plagued by small sample sizes and 'pseudo-replication', in which data are analysed assuming that each colony is independent, even though multiple colonies are housed within a single box, and so experience a common environment.

"Small sample size in field trials has been used as an excuse to not carry out formal analysis, and to draw a conclusion that there is no observable effect of neonicotinoids from visual inspection of the data.

"When analyses have been conducted, the problem of pseudo-replication has been ignored. In our field study, we used so-called 'random effects' to allow for pseudo-replication, and hence provide valid tests of the null hypothesis of no effect.

"Despite the limited true replication, we found very strong evidence that low levels of neonicotinoids have adverse effects on bumblebee colonies, with an estimated 55 per cent reduction in live bee numbers, 71 per cent reduction in healthy brood cells, and 57 per cent reduction in the total bee mass of a nest."

Provided by University of St Andrews