LWEC
Living With Environmental Change

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Protecting insect pollinators from pesticide risk

How can farmers and growers achieve effective crop protection while limiting pesticide risk to pollinators and the essential ecosystem services they provide?

Photo by Dr Christopher N Connolly, University of Dundee

Living With Environmental Change Policy and Practice Notes

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The Living With Environmental Change Partnership brings together 22 public sector organisations that fund, carry out and use environmental research and observations. They include the UK research councils, government departments with environmental responsibilities, devolved administrations and government agencies. The private sector is represented by a Business Advisory Board.

Pesticides can cause sub-lethal effects on the physiology and behaviour of beneficial insects which can, in turn, cause an impact on their survival and reproduction. The toxic effects of common pesticides are rarely highly specific and can pose a risk to beneficial insects such as pollinating bees.

How are insect pollinators exposed to pesticides?

Pesticides can be applied in a variety of ways and the method will affect how pollinators are exposed to these chemicals:

— Sprays may fall directly onto pollinators that are active on the crop during application, or insects could come into contact with residues when collecting nectar or pollen from crop flowers.

— Systemic pesticides can be applied as a seed-treatment or via irrigation, with the chemicals taken up from the soil as the plant grows. Pesticide residues may occur in both nectar and pollen, so the pollinator is exposed each time it feeds or collects food for offspring. Residues of pesticides in soil or water can also be taken up by wild flowers, increasing potential exposure to pollinators.

— Honeybees may be exposed directly to miticides, which are pesticides applied to hives by beekeepers to control *Varroa* mites.

What do researchers know about effects on pollinators exposed to low levels of pesticides?

There are many species of insect pollinator, but most studies focus on bees.

— Carefully controlled laboratory and semi-field experiments using a range of pesticides and exposure levels for both individual bees and colonies have revealed a range of connected sub-lethal impacts:
- Abnormal brain cell function.
- Impairment of learning, memory and navigation, so bees may fail to locate sources of nectar and pollen or to find their way back to their nest.
- Poor foraging performance, making bees less efficient at collecting pollen.
- Reduced colony growth.
- Impaired reproduction.

— The impacts on bee health from exposure to pesticide-treated crops can also be tested in field trials. However results of field trials are more difficult to interpret than laboratory studies because:
- They take place in a complex ecosystem in which other pesticides and diseases are likely to be present, and the availability of pollen and nectar and weather conditions will be variable.
- It is difficult to separate the effects of the pesticide being tested from these other factors.
- Exposure of bees to the pesticide may potentially be reduced as they forage widely in the landscape.

What are the limitations of pesticide risk assessments?

Currently the only pollinator species for which pesticide toxicity testing is required is the honeybee. Current testing is limited because:

— Exposure periods or experiments may be insufficient to detect chronic impacts.
— Combined pesticide toxicity is not studied except when active substances are marketed as a single formulation.
— A full disclosure of all additives, not just active substances, is required to assess the full risk of a formulation. Current legislation does not require disclosure of inert additives.
— Research shows susceptibility to a pesticide varies between pollinator species.
— Honeybees are an atypical bee species with large, perennial colonies that are managed by beekeepers and so are unlikely to indicate impacts in other pollinator species.
— Susceptibility to a pesticide may vary between development stages (eg eggs, larvae, adults) and castes (workers, queens and males). Currently, honeybee toxicity tests typically only consider adult workers.

How do pesticides, pathogens and habitat interact and increase harm to pollinators?

Pollinators, particularly bees, foraging in agricultural landscapes are exposed to multiple pressures during both their development and adult lives.

— **Multiple pesticides:** There are hundreds of different pesticides available for a variety of uses in the UK. Some may be mixed on site into combinations with unknown effects. For example, in experiments, at least three classes of insecticides (neonicotinoids, pyrethroids and organophosphates) that target the insect brain, have a greater negative impact on honeybees or bumblebees when combined.
— **Disease and parasites:** Greater susceptibility to insecticides has been reported when bees are infected with parasites or diseases.
— **Landscape:** Reduced availability and diversity of pollen and nectar in the landscape may lead to nutritional deficits in pollinators and increased susceptibility to pesticides and disease.

What needs to happen to minimise pesticide risks to pollinators?

Policymakers need to review procedures and ensure:

— Inclusion of more pollinator species in the pesticide risk assessment process to reflect the potential impacts on all insects.
— Development of chronic exposure testing protocols (eg European Food Safety Authority guidance) to test effects on pollinator behaviour (eg learning, memory and foraging) and/or to identify molecular biomarkers in pollinators for chronic toxicity.
— Evaluation of potential interactions between pesticides that may exacerbate impacts on pollinators (via additive or synergistic effects).
— Local pesticide usage records from farmers (mandated under EU regulations) are related to local insect abundance and diversity from long term monitoring projects.
— Agri-environment schemes are designed to incentivise Integrated Pest Management, and enriched landscapes and to minimise risks to pollinators.

Farmers, land managers and producers need to implement Integrated Pest Management approaches and use pesticides efficiently by:

— Limiting prophylactic use of pesticides and matching usage to real pest pressures.
— Targeting use of pesticides where they are most effective and least toxic. For example, by using neonicotinoids where their high insect toxicity and low mammal toxicity is beneficial (eg veterinary use), but limiting usage where risk to non-target organisms is greatest (eg insect pollinated crops).
— Avoiding spraying crops attractive to pollinators during flowering where possible but, when essential, spraying during the evening when fewer pollinators are flying to reduce exposure.
— Considering pesticide retention in soil when implementing crop rotations (eg potential uptake by incoming crop and subsequent pollinator exposure).
— Enriching the landscape by providing permanent habitat to supply sufficient foraging, nesting and overwintering resources for pollinators.

Further information

This Policy and Practice Note was written by Dr Christopher Connolly (University of Dundee), Prof Nigel Raine (University of Guelph) and Prof Geraldine Wright (Newcastle University) drawing on an Insect Pollinators Initiative research project. The UK Insect Pollinators Initiative is funded by the Biotechnology and Biological Sciences Research Council, the Natural Environment Research Council, the Department for Environment, Food and Rural Affairs, the Scottish Government, and the Wellcome Trust under the auspices of the LWEC partnership. Thanks to Dr Adam Vanbergen and Dr Matt Heard for helpful comments.

Useful resources:

Insect Pollinators Initiative: https://wiki.ceh.ac.uk/display/ukipi/Home

LWEC PPN 9 What is causing the decline in pollinating insects?: http://www.lwec.org.uk/sites/default/files/attachments_biblio/15742%20LWEC%20PP%20Note%2009_web.pdf

LWEC PPN 13 The benefits of managing pollinators for crop production: http://www.lwec.org.uk/sites/default/files/attachments_biblio/LWEC_PPNote13_WEB.pdf

Pesticide usage relating to Great Britain from 1990 onwards: http://pusstats.fera.defra.gov.uk/

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Chronic exposure to neonicotinoids increases neuronal vulnerability to mitochondrial dysfunction in the bumblebee (*Bombus terrestris*). 2015. Moffat, C, Goncalves Pacheco J, Sharp S, Samson AJ, Bollan KA, Huang J, Buckland ST, Connolly CN. FASEB J (Jan 29. pii: fj.14-267179.)

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Sublethal neonicotinoid insecticide exposure reduces solitary bee reproductive success. Sandrock C, Tanadini LG, Pettis JS, Biesmeiijer JC, Potts SG, Neumann P. 2014. Agricultural and Forest Entomology 16: 119-28

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European Food Safety Authority Guidance on the risk assessment of plant protection products on bees: http://www.efsa.europa.eu/en/efsajournal/pub/3295.htm

The formulation makes the honey bee poison. Mullin CA, Chen J, Fine JD, Frazier MT, Frazier JT. Pesticide Biochemistry and Physiology. 2015. http://dx.doi.org/10.1016/j.pestbp.2014.12.026

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