

## **New and emerging issue: Impacts of Neonicotinoid Insecticides on Biodiversity**

### **Why this issue needs urgent attention:**

Neonicotinoid insecticides are a relatively new, but widely-used, class of systemic, water-soluble nerve poisons. They are readily incorporated into all plant cells, as well as pollen and nectar. They act by binding to acetylcholine receptors of plant-feeding insects, inducing depolarization of motor neurons, tetanic contractions, neuromuscular destruction and death. Non-target plant-feeding insect groups (e.g., bees, certain moths and butterflies) exposed to these insecticides are at risk.

Declines in these insect groups are well documented, while noting that these declines can be attributed to habitat loss and invasive species as well as to pollution from neonicotinoid insecticides and other agricultural chemicals. In many agricultural areas, populations of animals that rely on plant-feeding insects as food sources (e.g., birds, bats, amphibians, predatory insects) are also declining. Neonicotinoid insecticides also bind to vertebrate acetylcholine receptors, posing direct risks to vertebrate herbivores such as birds that may consume neonicotinoid-coated seeds.

Many studies have documented deaths of honeybees and other plant pollinators exposed to neonicotinoid insecticides during agricultural operations. This creates threats to food security, placing at risk the global supply of the ~60% of crop plant species that are pollinator dependent. Adverse impacts of these insecticides on insect predators (rove beetles, carabid beetles, lady beetles, spiders) and potential losses of natural pest control services have also been addressed in a number of studies.

When neonicotinoid insecticides are applied repeatedly their rate of degradation is not always sufficiently rapid to avoid build-up in soils. At levels well below those that are directly toxic, neonicotinoid insecticides decrease activity (burrowing, feeding) of decomposer organisms such as earthworms. Similar adverse impacts have been observed on the activity of aquatic organisms that feed on plant residues. The water-soluble nature of neonicotinoid insecticides makes them susceptible to transport into aquatic habitats. When they are applied to rice crops, the normal suite of organisms found in rice paddies is drastically altered and may not recover over the duration of crop growth.

Exposure to neonicotinoid insecticides stresses the immune systems of animals and increases their vulnerability to other drivers of biodiversity loss, such as invasive pests and diseases. It has been suggested that the introduction of these chemicals coincides with, and is linked to, the explosion of emerging infectious diseases of wildlife in a wide variety of taxa, including honeybees, fish, amphibians, bats and birds (Mason, R. et al. 2012. Immune suppression by neonicotinoid insecticides at the root of global wildlife declines. *J. Environ. Immunol Toxicol* 1(1): 3-12).

### **How this issue affects the attainment of the objectives of the Convention:**

This issue has the potential to affect negatively the attainment of the first and second objectives of the Convention: the conservation of biological diversity, and the sustainable use of its components.

Recent assessments by regulatory authorities have documented negative impacts of neonicotinoid insecticides on plant pollinators, and in particular honeybees. There has been limited regulatory attention to their impacts on biodiversity more generally, particularly on the many species that occur in agricultural areas. This suggests the relevance of Article 7(c): "Each Contracting Party shall, as far as possible and as appropriate, in particular for the purposes of Articles 8 to 10... Identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biodiversity."

Many species groups found in agricultural areas (farmland birds, bats, butterflies, moths, fish and amphibians in watercourses receiving agricultural pollution, etc.) are declining, often at a faster rate than overall biodiversity. Various individual species within these groups have been assigned threatened status. This indicates the relevance of Article 8(f), “Rehabilitate and restore degraded ecosystems and promote the recovery of threatened species, inter alia, through the development and implementation of plans or other management strategies.”

If a scientific and technical analysis done by the Convention indicates that neonicotinoid insecticides do have adverse impacts on biodiversity more generally, Article 8(l) will be relevant: “Where a significant adverse effect on biological diversity has been determined pursuant to Article 7, regulate or manage the relevant processes and categories of activities.”

Documented impacts of neonicotinoid insecticides on plant pollinators, and consequent risks to the sustainability of agricultural production, indicate the relevance to this issue of Articles 10(a): “Integrate consideration of the conservation and sustainable use of biological resources into national decision-making”; and 10(b): “Adopt measures relating to the use of biological resources to avoid or minimize adverse impacts on biological diversity”.

#### Relevant existing CBD programmes of work and/or cross-cutting issues:

The Strategic Plan for Biodiversity 2011-2020 has three relevant targets:

- **Target 7:** By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity;
- **Target 8:** By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity; and
- **Target 12:** By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

The Programme of Work on Agricultural Biological Diversity, Decision VI/5, Annex II, International Pollinators Initiative, calls for “case-studies... to identify... threats to [pollinator] diversity, including, for example, use of pesticides...”

#### Work already under way by organizations addressing the issue:

Following a request by the European Commission, the European Food Safety Authority (EFSA) conducted assessments of three neonicotinoid insecticides – clothianidin, imidacloprid, and thiamethoxam - as regards their risks to bees. The EFSA has now placed a 2-year moratorium on selected uses (e.g., seed treatments) of these three neonicotinoid insecticides.

Other relevant government agencies (e.g., the Environmental Protection Agency in the United States) are reviewing their decisions regarding registrations of neonicotinoid insecticides.

#### Credible sources of information, preferably from peer-reviewed articles:

Buglife –The Invertebrate Conservation Trust prepared a 2009 report on *The impact of neonicotinoid insecticides on bumblebees, honey bees and other nontarget invertebrates* with over 100 references (<http://www.buglife.org.uk/Resources/Buglife/revised%20neonics%20report.pdf>). In 2012, Buglife reviewed 41 articles that had appeared since their 2009 report. They concluded that 31 of the papers “contained evidence that neonicotinoids would or could have significant environmental impacts above and beyond what was previously known” - see

<http://www.buglife.org.uk/Resources/Buglife/A%20review%20of%20recent%20research%20relating%20to%20the%20impact%20of%20neonicotinoids%20on%20the%20environment.pdf>).

The Xerces Society for Invertebrate Conservation prepared a comprehensive review of the literature relating to neonicotinoid insecticides and pollinators in 2012, *Are Neonicotinoids Killing Bees?* (<http://www.xerces.org/neonicotinoids-and-bees/>)

The American Bird Conservancy prepared an analysis of the scientific literature on neonicotinoid insecticides and birds in 2013, *The Impact of the Nation's Most Widely Used Insecticides on Birds*. ([http://www.abcbirds.org/abcprograms/policy/toxins/Neonic\\_FINAL.pdf](http://www.abcbirds.org/abcprograms/policy/toxins/Neonic_FINAL.pdf))

#### Relevance of this issue to the objectives of the Convention:

The issue of impacts of neonicotinoid insecticides on biodiversity is relevant to the first and second objectives of the Convention: the conservation of biological diversity, and the sustainable use of its components.

#### New evidence of unexpected and significant impacts on biodiversity:

The magnitude of impacts of neonicotinoid insecticides on biodiversity and non-target organisms was not foreseen when these chemicals were registered. An early study of imidacloprid (Pflüger, W. W., & Schmuck, R. R. 1991. Ecotoxicological profile of imidacloprid. *Pflanzenschutz-Nachrichten Bayer* 44(2): 145-158) examined “beneficial arthropods and other beneficial species; birds and mammals; and aquatic biocoenoses.” The authors concluded that “exhaustive tests for possible ecological effects demonstrate that although this compound is highly effective against a broad spectrum of pests, it is unusually safe in environmental terms.” Similarly, an early study of clothianidin (Schmuck, R. R., & Keppler, J. J. 2003. Clothianidin - ecotoxicological profile and risk assessment. *Pflanzenschutz-Nachrichten Bayer* 56(1): 26-58) concluded, based on “worst-case exposure and toxicity data for birds, mammals, and fish... that the use of clothianidin will pose only a negligible risk to these nontarget organisms under conditions of practical use.” The authors added that “the use of the compound as a seed dressing agent does not pose long-term risks to either terrestrial or aquatic nontarget arthropod species, as demonstrated in tests with simulated field exposure conditions.”

A possible explanation for the unexpected and significant impacts on biodiversity shown in more recent studies of neonicotinoid insecticides is that risk assessments for new chemicals (e.g., as described in the *OECD Manual for Assessment of Chemicals*) focus largely on acute toxicity. Chronic toxicity is only considered based on the physical and chemical (not biological) properties of a chemical proposed for registration. However, in the case of neonicotinoid insecticides, repeated exposures can cause chronic, cumulative neurological damage in non-target organisms (as well as in target pests). There is very strong experimental evidence of impacts at sub-lethal levels. Also, conventional risk assessments do not generally consider ecosystem-level impacts, e.g., on terrestrial and aquatic food chains.

#### Urgency of addressing the issue/imminence of the risk/magnitude of actual and potential impact on biodiversity:

Many groups of organisms found in agricultural areas are experiencing catastrophic declines, including:

- birds (e.g., Nebel, S. et al. 2010. Declines of aerial insectivores in North America follow a geographic gradient. *Avian Conserv. Ecol.* 5(2): 1. [\[online\]](#));

- bats (e.g., Wickramasinghe, L.P. et al. 2004. Abundance and species richness of nocturnal insects on organic and conventional farms: effects of agricultural intensification on bat foraging. *Conserv. Biol.* 18: 1283–1292);
- amphibians (e.g., Blaustein, A.R. 2011. The complexity of amphibian population declines: understanding the role of cofactors in driving amphibian losses. *Ann. N. Y. Acad. Sci.* 1223: 108-119);
- bumblebees (e.g., Cameron, S.A. et al. 2011. Patterns of widespread decline in North American bumble bees. *Proc. Nat. Acad. Sci.* 108(2): 662-667);
- butterflies (e.g., Van Dyck, H. et al. 2009. Declines in common, widespread butterflies in a landscape under intense human use. *Conserv. Biol.* 23(4): 957-965);
- moths (e.g., Conrad, K.F. et al. 2006. Rapid declines of common, widespread British moths provide evidence of an insect biodiversity crisis. *Biol. Conserv.* 132(3): 271-291); and
- carabid beetles (Brooks, D. R. et al. 2012. Large carabid beetle declines in a United Kingdom monitoring network increases evidence for a widespread loss in insect biodiversity. *J. Appl. Ecol.* 49(5): 1009-1019).

There is an urgent need for greater understanding of the degree to which exposure to neonicotinoid insecticides may be contributing to these declines, and how exposure to these chemicals may be interacting with other negative pressures on biodiversity in agricultural areas.

Actual geographic coverage and potential spread, including rate of spread:

Neonicotinoids are now the most widely used crop insecticides in the world. They are marketed in over 120 countries to protect more than 140 crops.

Evidence of the absence or limited availability of tools to limit or mitigate the negative impacts of the issue on conservation and sustainable use:

With older classes of pesticides whose mode of action is based on acute toxicity, farmers could practice integrated pest management – using tools such as regular surveys of crop fields for pest outbreaks, and spraying only when outbreaks occur. These integrated pest management tools resulted in reduced chemical use and thereby mitigated negative impacts on non-target organisms, at least to a degree.

In contrast, systemic pesticides (such as neonicotinoid insecticides) are continuously present during the entire period of crop growth. This makes it difficult to avoid exposure of non-target organisms to these pesticides. The limited availability of integrated pest management tools specifically applicable to systemic pesticides poses unique challenges for conservation and sustainable use of biodiversity.

Magnitude of actual and potential impact on human well-being:

To date, concern about impacts of neonicotinoid insecticides on human well-being have largely focused on their unintended negative effects on pollinating insects (and to a lesser extent, predatory arthropods) and consequent effects on agricultural crop production. There is already evidence that over the period 1961-2008, food crops with greater pollinator dependence had lower mean and stability in relative yield and yield growth, despite global yield increases for most crops (Garibaldi, L.A. et al. 2011. Global growth and stability of agricultural yield decrease with pollinator dependence. *Proc. Natl. Acad. Sci.* 108(14): 5909-5914). Relatively poor yields of pollinator-dependent food crops are worrisome from a nutritional standpoint, because these are mainly fruits, nuts and vegetables rich in vitamins and mineral nutrients.

Concern has also arisen about impacts of neonicotinoid insecticides on the ecosystem service of crop residue decomposition/nutrient cycling, in light of the evidence that these chemicals have negative impacts on earthworms and other decomposer organisms. This also could, at least in the longer term, reduce crop yields, or compel farmers to increase their use of chemical fertilizers.

Neonicotinoid insecticides have documented negative impacts on aquatic food webs, thereby raising concerns about loss of productivity in freshwater fisheries and aquaculture systems.

A recent study (Kimura-Kuroda, J. et al. 2012. Nicotine-like effects of the neonicotinoid insecticides acetamiprid and imidacloprid on cerebellar neurons from neonatal rats. PLoS ONE 7(2): e32432.) indicates that the neonicotinoid insecticides acetamiprid and imidacloprid exert excitatory effects on mammalian acetylcholine receptors similar to nicotine, a neurotoxin of brain development and a known risk factor for sudden infant death syndrome, low-birth-weight infants, and attention deficit/hyperactivity disorder. This raises concerns that neonicotinoid insecticides may adversely affect human health, especially the developing brain.

Actual and potential impact on productive sectors and economic well-being:

The strongest evidence for actual adverse impacts of neonicotinoid insecticides on productive sectors relates to yield of pollinator-dependent crops. For example, almond producers in California, USA, are highly dependent on pollination services provided by honeybees that are trucked into orchards during the period when trees are flowering. Losses of honeybee colonies during the winter of 2012-2013 were so great that there were fears that some trees would go unpollinated. Beekeepers brought in hives at the last minute from around the country. With good weather and a prolonged period of flowering, the crisis was mostly averted in 2013. However, such heroic measures are costly and unsustainable.

Potential impacts of continued use of neonicotinoid insecticides must be examined in the context of a broader suite of factors affecting agricultural productivity and sustainability. Long-term economic well-being of the agriculture sector will require greater efforts to reduce its reliance on external chemical inputs and fossil fuels, so as to maintain food security and avoid unpredictable spikes in food prices.

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30 June 2013