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IV. NEONICOTINOIDS: EFFECTS ON BIODIVERSITY AND ECOSYSTEMS

→ the issue of highly toxic pesticides in the world

By Jean-Marc Bonmatin

Summary of the presentation Neonicotinoids act on the central nervous system, not only of insects but also of mammals. Their impact is greatest on pollinators, but also on soil invertebrates and all aquatic invertebrates. They also affect vertebrates, such as fish and common birds. The question arises as to their effects on mammals and in particular on humans. These molecules, which have contaminated the planet, pose a threat to public health. There is consensus on this point and there is an urgent need to act by giving priority to integrated pest management techniques and organic farming.



- Doctor in Chemistry-Physics,
- Researcher at the Department of Molecular Biophysics of the National Center for Scientific Research (CNRS) of Orléans,
- Vice-President of the Task Force on Systemic Pesticides, a working group created in 2009 to conduct research on the environmental impact of the use of neonicotinoids and their effects on biodiversity and ecosystems. He is the main author of WIA 2015 (Worldwide Integrated Assessment) which analysed more than 2 000 studies on neonicotinoids.

Jean-Marc Bonmatin's studies are located at the intersection of chemistry, biology and toxicology, and concern the contamination of living systems with pesticides (in particular neonicotinoids). He is about to publish a second meta-analysis on the subject.

PRESENTATION

My presentation will focus on the much broader effects of using systemic pesticides, particularly neonicotinoids, on biodiversity and ecosystems. [...] We will be talking about bees and imidacloprid, and the archetypal molecule of neonicotinoids. As you will see through my presentation, science has already done a great deal to illustrate the effects of these molecules.

Neonicotinoids are a small family of molecules that act on the central nervous system, not only of insects but also of mammals to a lesser extent. We can discuss the classification of these neonicotinoids at a later stage, if you wish. From the chemist's point of view, we consider two subclasses of neonicotinoids, including sulfoxaflor and flupyradifurone, which belong to the neonicotinoid class. Neonicotinoids are a dozen molecules that act on the central nervous system of insects to destroy them when used in agriculture. By blocking the ion channels, the insect is killed in seconds or minutes depending on its size.

We've done a great deal of research on this. To sum up: in 2014 on the internet and in 2015 in hard copy, we published a set of eight peer-reviewed scientific reports, which already raised the issue of the impact of neonicotinoids on biodiversity. Most recently, in 2017, we released a series of articles that update this global assessment - because we operate internationally - of the effects of neonicotinoids on biodiversity and ecosystems. So I'm going to focus a little more on the exposure issues of non-target organisms, that is, organisms that are not affected by the use of these pesticides. What are the consequences of their exposure on their metabolism? We will discuss insect and invertebrate populations, as well as vertebrates and the impacts these molecules have on ecosystems in general. Then we can open the debate to the question of resistance, i.e. all those molecules that have produced resistance in pests and are therefore less and less useful in the end. Finally, we can see that alternatives to neonicotinoids exist and are numerous. If you ask me, I can show you that certain alternatives are extremely effective and can replace the systematic and preventive use of these molecules.

Our work consisted of a global risk assessment. This requires two things: measuring actual exposures in the nature of non-target species, and measuring the effects. When you obtain both the exposure measure and the effects sensitivity measure, you can assess the risks, that's the definition. This then allows us to give advice on protecting pollinators but also ecosystems in general, and then, you will see, perhaps even public health.

Concerning bees, this has been heard and demonstrated for some years now. **Whether bees, bumblebees or wild pollinators, the four major threats that explain their decline are:**

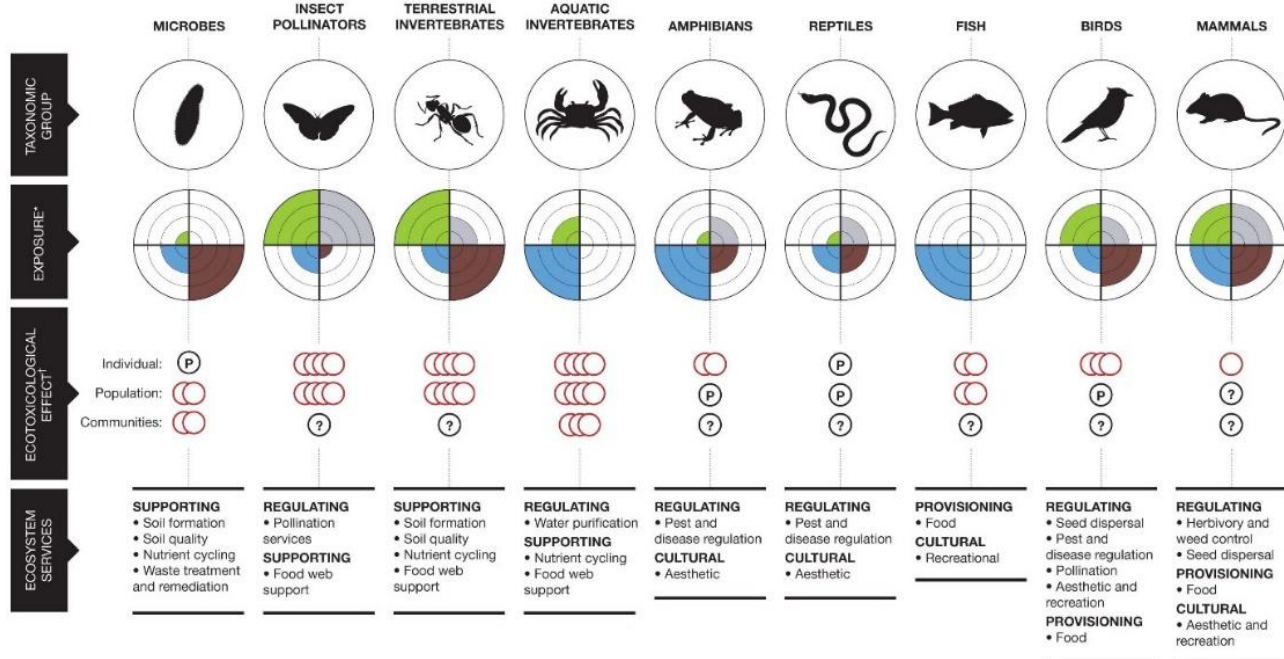
- lack of floral resources,
- the presence of pesticides, especially neonicotinoids,
- the pyrethroid family,
- the presence of pathogenic parasites.

I would also like to stress that it is indeed neonicotinoids that promote the appearance and development of parasites and pathogens in pollinators. So to all those who claim that "they are diseases, they are parasites of the varroa type that decimate pollinators", I remind them that the proof has been shown: in the presence of pesticides and in particular neonicotinoids, these

diseases and these parasites develop more and obviously lead to the decline of pollinator colonies.

What applies to pollinators also applies to other systems. For scientists, it is understood and agreed: **only a small part of the neonicotinoids go up into plants to protect them from pests. The vast majority remains in the ground.** There is very significant and persistent contamination. Then **these molecules are leached, and end up in surface water, where they can impact aquatic invertebrates.** As my colleague said, pollinators are just the tip of the iceberg. In fact, the exposure of a whole series of soil and aquatic invertebrates worries us more, especially since the life span of these molecules is very long. **Some can contaminate the environment up to 30 years.** So a systematic use of these molecules every year, or even twice a year, will obviously contaminate the soil consistently.

Degrees of exposure and respective toxicity of systemic pesticides to different categories of non-target organisms: the last row of the table details the ecosystem services provided by each family of organisms, provided free of charge and threatened by the use of pesticides.



*EXPOSURE
 0: No route of exposure
 1: Potential route of exposure assumed negligible
 2: Relevant route of exposure low
 3: Relevant route of exposure moderate
 4: Relevant route of exposure high

†ECOTOXICOLOGICAL EFFECT
 1: Potential effects assumed negligible under normal exposure conditions
 2: Evidence effects can occur but at high doses or after prolonged exposure
 3: Evidence effects can occur at moderate doses
 4: Evidence effects can occur at low doses or after acute exposure
 (?) Unknown: in situations where no judgement could be made because of lack of evidence, e.g. data unavailable
 (P) Probable: no accurate judgement could be made due to incomplete evidence, but data suggests a potential effect level above (1)

The diagram (above) summarises all of our results. Of the diversity of species that make up biodiversity, **pollinators are most impacted by neonicotinoids** (four red pellets). But what we discover on this chart is that **the impact is greatest at the level of individuals, populations and communities, not only for pollinators, but also for soil invertebrates and all aquatic invertebrates.** It should be remembered that terrestrial and aquatic invertebrates are at the base of the food chain, and the work of researchers Kroon and Hallmann shows that we are capable of measuring

the effects of the decline of these invertebrates. Then, to a lesser extent, there are also impacts on amphibians and reptiles. But that is not all, and I would like to stress this: there are significant impacts on vertebrates, whether at the level of individuals, populations or even communities, as we have seen in fish and common birds.

Then, we can ask ourselves the question regarding the impacts on mammals and in particular on humans. What we found for pollinators - through the many impact studies, especially on the major functions of reproduction but also of the development - also applies to humans, with exactly the same effects ... We have seen this through the studies that are available, although few in number.

Our conclusions are very simple. Neonicotinoids have five main characteristics:

- they are used heavily on the planet,
- they are used prophylactically, that is to say in a preventive way, without even knowing if they are needed,
- they have a very high toxicity for all invertebrates, and a high toxicity for vertebrates,
- they remain in soils for a long time,
- they are leached by water and contaminate deep surface waters.

There is therefore a widespread contamination of the planet by these molecules. To give you an idea of the magnitude, about 20,000 tons per year of neonicotinoids are poured on the planet, knowing that it only takes one nanogram for them to have a deadly effect on bees. 20,000 tonnes, how many nanograms are likely to act on living organisms? We are talking here about pharaminous quantities.

Our conclusions of course link neonicotinoids and the decline of pollinators, but also of terrestrial organisms and aquatic invertebrates. Moreover, there are more and more impacts on ecosystems. It is a threat to the ecosystem services, on which agriculture and the way we feed the planet depend. It is paradoxical: under the pretext of obtaining better productions, pesticides are used that threaten not only food security (quantity of production) but also the quality of what we consume. It is a threat to public health. I agree with my peers: this observation is clear, there is consensus and urgent action is needed. Although decisions were made on this in 2013, I think we need to go further. I don't do politics here, I do science. I rely on facts and there is no doubt about it. **I believe that action must be taken, either by reducing or prohibiting these pesticides, in accordance with the wishes of the States. In any case, integrated control techniques and organic farming should be favoured.** We urgently need to reduce the amount of neonicotinoids and systemic pesticides that are being dumped on the planet.

I would like to thank certain organisations, including the Task Force to which I belong and of which I am Vice-President, the European Union which financed part of the studies, the French government and the

National Center for Scientific Research (CNRS), as well as the entire community of scientists who have worked with me for about ten years, that is to say, sixty people on four continents and who represent nearly 23 countries.