Developing a mechanism for supporting better decisions on our environment based on the best available knowledge.

EKLIPSE Document of Work:
"Pollinators" request

CONTENT

GENERAL INFORMATION

What are the impacts of pesticide and fertiliser use in farmland on the effectiveness of adjacent pollinator conservation measures such as flower strips and hedgerows?

This request was initially put to EKLIPSE following our third call for requests (CfR.3/2018) by Pollinis, a European NGO based in France, which campaigns for the protection and conservation of pollinators, notably bees, and promotes the transition towards alternative agricultural practices, away from the systematic use of pesticides in Europe.

Requesters: Pollinis
Date request received: 30th June 2018
Date of first meeting with requesters, EKLIPSE KCB and methods experts: 09/01/2019
Expected deadline for deliverables: December 2019/ January 2020

This Document of Work (DoW) explores the existing knowledge in this area, who the main knowledge holders are, how the request relates to existing policy processes at the EU level, and identifies the most suitable programme of work and methodology for answering this request.

BACKGROUND AND CONTEXT OF THE CALL

Background

As stated in the Initial request, "pollinator decline is a major issue in agriculture: not only causing a decrease in outputs, but also quality and nutritional value. Particularly, there is a mutual and beneficial relationship between hedgerows and wild pollinators. Therefore, agricultural practices should evolve in line with protecting pollinators, as well as to create an environment to meet their needs (i.e. through food and habitats). Hedgerows and grasslands presents numerous interests for pollinators. "

The initial request was formulated this way: "There exist few information about how to manage or cultivate hedgerows in order to effectively increase pollinator population. There requires a study to investigate the importance of the hedgerows and its relationship to the wild pollinators."

The Strategic Advisory Board (SAB) of EKLIPSE advised to enlarge the subject to agricultural landscapes (not only hedgerows) and all pollinators (not only wild).

After the 1st scoping meeting, it appears Pollinis is very interested in the impacts (direct and indirect) of pesticides (particularly SDHI - succinate dehydrogenase inhibitors - fungicides) on pollinators.
It was agreed that the request should focus on the interactions between conservation actions aimed at pollinator conservation, and pesticides and how it affects pollinators.
The research question was reformulated:
- What are the interactions between conservation actions aimed at pollinators, and pesticides?
- What is the effect of pesticides on conservation actions and how does this affect pollinators?
The request could address other agricultural landscapes than only hedgerows (grass margins, flower strips, ponds for example), but not all agricultural landscapes, as it would be too broad.

The general objective of the request would be to better understand how to plant agricultural infrastructure which can help pollinators in the best and more sustainable way possible. It would contribute to the work POLLINIS is already doing in the field[1]; especially how to plant hedgerows, fields, cover-crops (e.g. mustard), trees, riverbanks and create stonewalls with different communities to make pollinator life more sustainable.
There are two major problems for pollinators: pesticides and the lack of resources (habitat and food) for pollinators. When agro-infrastructure are being reintroduced, it is needed to make sure these actions are indeed helping pollinators (benefits for them) and not harming them and not doing nothing (zero impact – waste of resources).

Still, the question of which landscape elements are best for pollinators is not the focus of this request, as it is already well covered by available knowledge syntheses. It is rather: what is the use of conservation measures (in this case, landscape elements for pollinators) if other practices (in this case pesticide use) negate them?

Policy relevance and timeliness of the request

[1] Currently, members of the POLLINIS team work with one farmer (central region of France) and another group works with 10 farmers via L'Association Française Arbres Champêtres et Agroforesterie (AFAC) working on farm landscape on planting hedgerows which have been shown to be useful to pollinators.

A number of policy actions at the European level are now in place that may support populations of pollinators and ensure the sustainable provision of pollination services. These include different measures under the EU Common Agricultural Policy (CAP): voluntary agri-environment and climate adaptation/mitigation measures under the rural development policy, as well as cross compliance and the 3 mandatory "Greening" measures under Pillar 1 (crop diversification, maintenance of permanent grassland and 5% of arable land dedicated to Ecological Focus Areas (EFA), for example trees, hedges.)

The recent "EU Pollinators' Initiative" sets strategic objectives and a set of actions to be taken by the EU and its Members States to address threats to pollinators. One action under this EU Pollinators' Initiative is the development of a guidance document on land management practices that benefit pollinators, which is aimed at managing authorities, advisory services and farmers.

Part of this guidance will cover pollinator conservation measures, such as management of field margins, hedgerows or other non-cropped habitat. There remains, however, a need to understand better the impact of actions in the wider environment on these pollinator conservation measures. In particular, there is a need to determine the impact of pesticides and fertilisers in farmland on adjacent pollinator conservation measures, in order to develop guidelines on the most effective pollinator-friendly agro-infrastructure. For example, systematic insecticides and fungicides have been found to contaminate wild flowers growing adjacent to arable fields (Botias et al 2015, 2016; David et al 2016)[2].

Timeline
Pollinis plans to organise a conference in **November 2019** on SDHI. If the EKLIPSE outputs leads to a link between pesticides and hedgerows, and impacts on pollinators, it could feed into this conference.

The guidelines with best management measures for pollinators from DG ENV should be ready **by the end of 2019.** They will be then updated, probably before the start of the new CAP 2021-2027.

Added Value of EKLIPSE

Due to the high level of controversy (campaigners vs scientists, NGOS vs pesticides firms…), EKLIPSE would ensure a transparent and neutral approach – as used in all other requests.

Call for Knowledge

A Call for Knowledge related to this request was carried out and open from the 21st of May until the 20th of June 2019. The Call for Knowledge was hosted on the KNOCK Forum and resulted in 10 contributions from experts as well as the identification of relevant publications. For details, see Annex 2.

[2] Botías, C., David, A., Hill, E.M., Goulson, D., 2016. Contamination of wild plants near neonicotinoid seed-treated crops, and implications for non-target insects. Sci Total Environ 566-567, 269-278.

Botías, C., David, A., Horwood, J., Abdul-Sada, A., Nicholls, E., Hill, E., Goulson, D., 2015. Neonicotinoid Residues in Wildflowers, a Potential Route of Chronic Exposure for Bees. Environmental Science & Technology 49, 12731-12740.

David, A., Botias, C., Abdul-Sada, A., Nicholls, E., Rotheray, E.L., Hill, E.M., Goulson, D., 2016. Widespread contamination of wildflower and bee-collected pollen with complex mixtures of neonicotinoids and fungicides commonly applied to crops. Environ. Int. 88, 169-178.

REFINED RESEARCH QUESTION

What are the impacts of pesticide and fertiliser use in farmland on the effectiveness of adjacent pollinator conservation measures such as flower strips and hedgerows?

SUGGESTED PROGRAMME OF WORK AND METHODS

Initially, the following methods were suggested to address the request:

a. Experts consultation - especially if the scoping review provides sufficient information
b. Joint fact finding (JFF), to gather different stakeholders, but could be premature
c. Rapid evidence assessment: if there is a limited set of keywords, but we have to look for specific aspects (like pesticides and hedgerows);

Following the results of the call for knowledge, the method selected would be the **first phase of the Joint Fact Finding** activity.

It's a way of identifying a shared consensus understanding of the knowledge gaps and planning how to address them. We may find that some questions are being addressed already, and there is definitely an opportunity for research questions that arise to be written into grant applications, in which researchers work in partnership with NGOs and industry.

This process requires a convener and an additional neutral person who can compile the information and deliver the administrative elements.

Next steps:

- develop a Protocol asap for review in July 2019
- Set up a coordination team (made up of KCB members - all ideally) and a dedicated person (trained facilitator) from August/September onwards to manage the fact-finding process –
- Workshop would be planned for **November 2019**

For more information on each of these methods, please refer to the EKLIPSE report on knowledge synthesis methods[3].

[3] Dicks LV, Haddaway N, Hernández-Morcillo M, Mattsson B, Randall N, Failler P,Ferretti J, Livoreil B, Saarikoski H, Santamaria L, Rodela R, Velizarova E,and Wittmer H. (2017). Knowledge synthesis for environmental decisions:an evaluation of existing methods, and guidance for their selection, use anddevelopment – a report from the EKLIPSE project

LOGBOOK

The logbook describes the agenda of exchanges with the Requester, the Knowledge Coordination Body (KCB) and the Methods group and the contents discussed during the meetings.

Date	Participants	Topic	Platform
09.01.2019	Lynn Dicks, Juliette Young, Flore Jeanmart, Joann Sy (Pollinis)	1st scoping group meeting	Online (Gotomeeting)
19.03.2019	Flore Jeanmart, Vujadin Kovacevic (DG ENV)	Policy relevance of the request	Phone
28.03.2019	Joann Sy, Vujadin Kovacevic (DG ENV), other members of Pollinis	Topic of the request	Phone
04.04.2019	Juliette Young, Joann Sy	To discuss the next steps	Online (Gotomeeting)
13.05.2019	Juliette Young, Alan Watt, Joann Sy	To discuss the refined question of the request	Online (Gotomeeting)
17.05.2019	Juliette Young, Alan Watt, Flore Jeanmart, Joann Sy	Call for Knowledge preparation	Online (Gotomeeting)
27.06.2019	Juliette Young, Alan Watt, Lynn Dicks, Flore Jeanmart, Joann Sy	Call for knowledge results, chosen method to address the question (JFF) and next steps	Online (Gotomeeting)

Annex 1: Call for Knowledge

EKLIPSE

Knowledge & Learning Mechanism on Biodiversity & Ecosystem Services

Developing a mechanism for supporting better decisions on our environment based on the best available knowledge.

EKLIPSE is developing a European Mechanism to answer requests from policy makers and other societal actors on biodiversity related issues

More information on the processes and the EKLIPSE project funded by the EU in H2020 is available at ***www.eklipse-mechanism.eu***

CALL FOR KNOWLEDGE FOR INITIAL SCOPING – CfK 01/2019, EKLIPSE – MAY 2019

Responses by: June 20th 2019

TOPIC:

What are the impacts of pesticide and fertiliser use in farmland on the effectiveness of adjacent pollinator conservation measures such as flower strips and hedgerows?

Invitation to share knowledge for informed decision-making

A number of policy actions at the European level are now in place that may support populations of pollinators and ensure the sustainable provision of pollination services. These include different measures under the EU Common Agricultural Policy (CAP): voluntary agri-environment and climate adaptation/mitigation measures under the rural development policy, as well as the 3 mandatory "Greening" measures under Pillar 1 (crop diversification, maintenance of permanent grassland and 5% of arable land dedicated to Ecological Focus Areas (EFA), for example trees, hedges.)

The recent "EU Pollinators' Initiative" sets strategic objectives and a set of actions to be taken by the EU and its Members States to address threats to pollinators. One action under this EU Pollinators' Initiative is the development of a guidance document on land management practices that benefit pollinators, which is aimed at managing authorities, advisory services and farmers.

Part of this guidance will cover pollinator conservation measures, such as management of field margins, hedgerows or other non-cropped habitat. There remains, however, a need to understand better the impact of actions in the wider environment on these pollinator conservation measures. In particular, there is a need to determine the impact of pesticides and fertilisers in farmland on adjacent pollinator conservation measures, in order to develop guidelines on the most effective pollinator-friendly agro-infrastructure. For example, systematic insecticides and fungicides have been found to contaminate wild flowers growing adjacent to arable fields (Botias et al 2015, 2016; David et al 2016).

EKLIPSE is therefore inviting scientists, policy makers, practitioners and other societal actors to share their knowledge on this specific selected request to explore available resources and evaluate if the request requires a knowledge synthesis process, structured knowledge gap analysis and/or consultation on research priorities.

To scope current knowledge on the impacts of pesticide and fertilizer use in adjacent farmland on the effectiveness of pollinator conservation measures, we invite you to answer the following questions:

- Do you know of any projects, papers, reports, grey literature that have or are exploring the impacts of pesticide and fertiliser use in adjacent farmland on the effectiveness of pollinator conservation measures such as flower strips and hedgerows?
- Could you share your experiences of on-the-ground actions aiming at understanding and increasing the effectiveness of pollinator conservation measures such as flower strips and hedgerows where pesticides and fertilisers are used in nearby farmland? These can be successful or unsuccessful processes – we can learn from both!
- Do you have any suggestions on what knowledge is needed to better understand the impact of pesticide and fertiliser use in adjacent farmland on the effectiveness of pollinator conservation measures such as flower strips and hedgerows or how existing knowledge could be better mobilized to this end?

The final framing of the request is being developed through an interactive dialogue between the EKLIPSE scientists and the requester (POLLINIS), and will be further discussed with stakeholders such as DG ENV and DG AGRI to ensure relevance for policy making regarding biodiversity and ecosystem services. We want to explore the amount of knowledge that exists in this area, who the main knowledge holders are and, if after scoping we decide to answer this request, we want to identify the most suitable methodology for answering it.

Please contribute your comments and knowledge/references through the online KNOCK forum.

How to contribute to the Call for Knowledge

All knowledge collected through this call for knowledge will be collected and discussed on the KNOCK Forum. To upload documents and participate in the discussion, please register at our quick and easy 'Keep me Posted' page. Then, please click on the relevant thread to upload your information. Each thread already contains documents that are potentially relevant to the request. We invite you to add any information that you think is relevant for this request, and justify its inclusion (e.g. additional information from countries, scales or disciplinary perspectives not covered sufficiently etc…). Relevant information should be grouped under the following headings: **1) literature reviews, 2) empirical studies/practical experiences, 3) modelling studies and 4) conceptual papers** and can include:

- Links to open access papers.
- Links to published and unpublished grey literature or case studies.
- Description of on-going research projects, or knowledge compilations, expected to deliver results within the next year.

- Your on-the-ground experiences in this field.

Objective of the call and request to be addressed by this call

EKLIPSE coordinates innovative and transparent approaches for science, policy and societal actors to jointly provide the best available evidence leading to better informed decision-making and to identify current and future research priorities. A request on whether missing knowledge is hampering the effectiveness of approaches that aim to restore biodiversity and ecosystem function and services was proposed by POLLINIS to the third EKLIPSE Call for Requests (CfR.3/2018). The objective of this call for knowledge is to launch an initial scoping process on the request meant to identify available assessments, existing studies and other resources.

Background on EKLIPSE

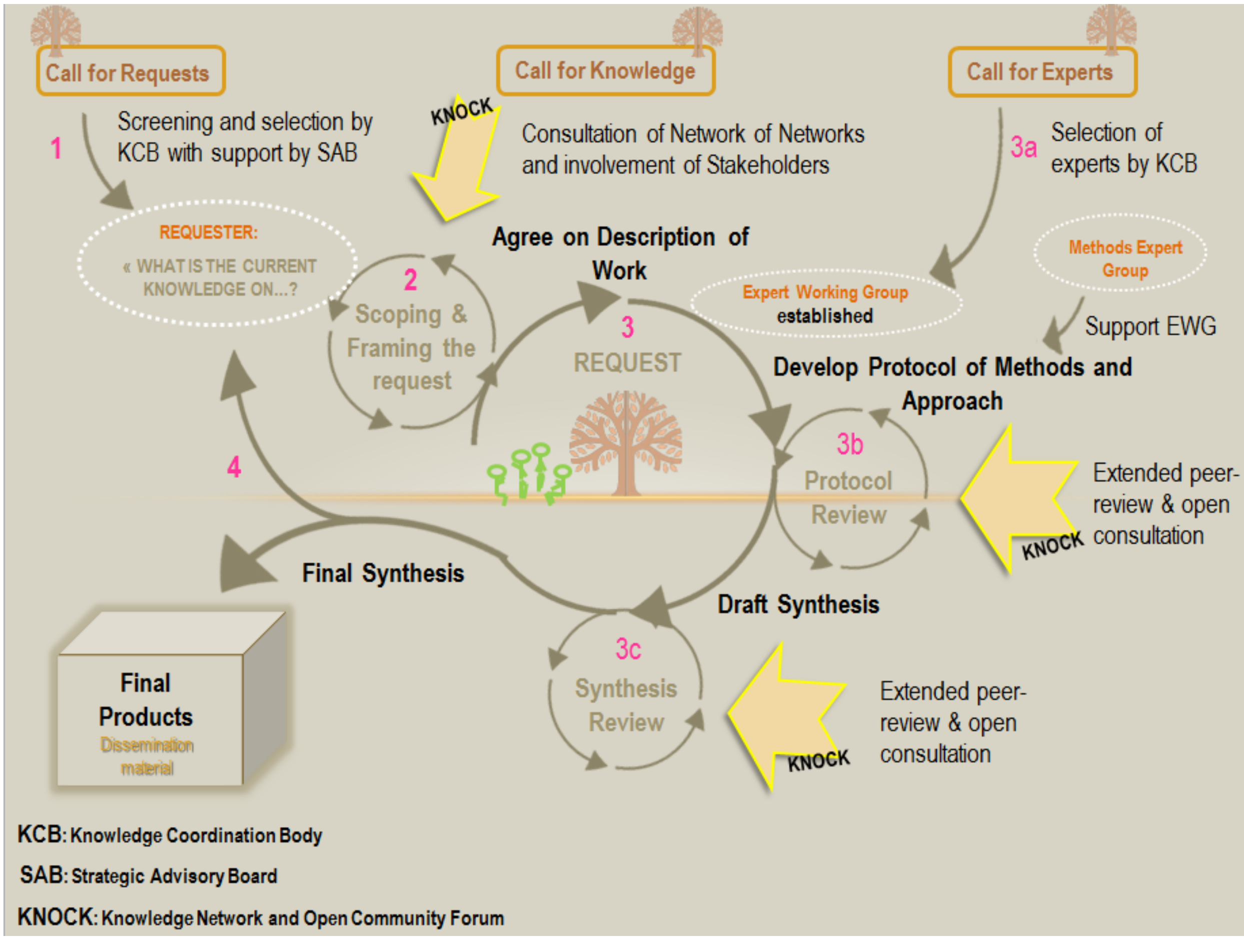
EKLIPSE is an EU-funded project that started in February 2016. With support from the European Commission and a high level Strategic Advisory Board (SAB), the project aims to establish a robust and flexible long-term mechanism for policy support on biodiversity and ecosystem services, communicating and engaging a wide set of knowledge holders and ensuring tailor-made outreach of results to knowledge requesters and society more broadly.

The success of EKLIPSE and its resulting mechanism is in everyone's hands:

- the 'requesters' from policy and society who need to know what knowledge is out there to answer their policy or societal needs;
- the knowledge holders (be they scientists or other citizens) who want their knowledge to mean something; and
- the extensive networks working on biodiversity and ecosystem services who have the enthusiasm and knowledge to make the mechanism work in the long term.

The process: how EKLIPSE answers requests

The EKLIPSE process consists of several steps (see figure below): After the Call for request (step 1), the second step is the Call for Knowledge that supports further Scoping and Framing the request (step2). Based on the findings of the Call for Knowledge, EKLIPSE and the requester discuss how to proceed with the request (step 3). If already sufficient knowledge on the request is available or other reasons exist for not continuing with the request, the request will not be taken further, and the outcome is the collection of knowledge identified in second step. If EKLIPSE and the requester agree on continuing, the request will be framed and finalised jointly with relevant science, policy and societal actors. EKLIPSE then organizes a Call for Experts inviting experts to form an expert working group on the request (step 3a).
The selected expert group will, together with the Knowledge Coordination Body (KCB) and the requester, agree on the methodological approach to be taken for the knowledge synthesis. This will be compiled in a protocol, made publicly available and peer reviewed (step 3b). During the process of gathering, integrating and synthesizing the best available evidence, communication between all relevant actors will be key. Finally, the results of the co-generated evidence will be peer reviewed before being communicated in targeted ways to the requester (e.g., as a report or brief or other output to be discussed with the requester), as well as relevant decision-makers, the knowledge community and the general public (steps 3 c and step 4).



Next steps: How EKLIPSE will continue with this request

If EKLIPSE decides to carry out a new knowledge synthesis based on the responses to this call for knowledge, it will invite experts on the topic to express their interest in joining the Expert Working Group. The expert working group will cover diverse and complementary skills (including multidisciplinary skills and a broad geographical coverage) and will interact with relevant stakeholders to ensure appropriate methodological choices and uptake of outputs.

The Call for Experts will be widely publicized on the EKLIPSE website, on the Forum and other dissemination channels to ensure a broad coverage of disciplines and geography. The selected group will be supported financially by the EKLIPSE project for travel expenses and in certain cases through honorary contracts.

Annex 2: Results of the Call for Knowledge

SUMMARY

General: The Call for Knowledge ran from the 21st May to the 20th June 2019. Ten external responses were received in the Call (for full responses see Appendix 1). The total number of views of these responses was 157 times.

Current knowledge: According to participants, there were a few known facts regarding the impact of pollinator-friendly structures:

- Flower strips and hedgerows adjacent to IP-apple orchards (high in pesticides) attract bees and hoverflies in high numbers when they are in flower, the key issue being the availability, quantity and quality of floral resources.
- Land-use change, conventional agricultural management and pesticide use represent a major risk to pollinators and pollination. For example, studies in the US have found that the pollen and nectar in flowers in pollinator strips adjacent to crops were so polluted with neonicotinoids that they caused harm to honeybees and prevented wild bees from reproducing successfully. Whilst exposure of bees to neonics was much higher close to neonic treated crops, even wildflower strips 150 metres away from treated crops caused significant exposure to the Honeybees. Other studies that detected high levels of neonics in pollen and nectar in field margin plants, including Greatti et al. 2006, Krupke et al. 2012, Pettis et al. 2013 (data), David et al. 2016 and Mortl et al. 2018.
- But agricultural management more sympathetic to beneficial biodiversity can be part of the solution (IPBES, 2016; Kovács-Hostyánszki et al., 2017; Potts et al., 2016). Planted crop margins do provide lots of great resources for bumblebees, butterflies and other insects (Pywell et al. 2011, Carvell et al. 2005, Carvell et al. 2006, Blake et al. 2011, Thomas and Marshall 1999, Haaland et al. 2011).
- Conclusions of a global meta-analysis (Kennedy et al., 2013) on local and landscape effects on wild bee pollinators were that farm-scale simplification of fields (monoculture) increases the importance of the quantity and diversity of semi-natural in the surrounding landscape. Conversely, field diversification lowers this reliance on landscape quality for bees.
- There is evidence of positive relationships between native bee richness, abundance and flower visitation and landscape-scale semi-natural habitat and negative relationships with agricultural management intensity (including pesticide use or proxies thereof) (Kennedy et al., 2013; Nicholson et al., 2017). There are links between semi-natural habitat, ecological restoration, pollinator visitation and diversity and pollination of crops and wild plants (Garibaldi et al., 2016; IPBES, 2016; Kovács-Hostyánszki et al., 2017; Pywell et al., 2015).
- There is also evidence that organic farms (with low or no pesticide use) tend to support greater local numbers and richness of foraging insect pollinators, and some evidence that it can benefit pollination, although this effect tends to be reduced in already diverse, heterogeneous landscapes (IPBES, 2016; Kennedy et al., 2013).
- On-farm semi-natural habitats, such as hedgerows and sown flower margins, provide food and nesting resources for insects, including pollinators and natural pest control agents, increasing

their activity, and with emerging evidence of population benefits (Carvell et al., 2017; Haenke et al., 2014; Jha and Kremen, 2013; Kremen et al., 2018; Ponisio et al., 2016).

- A limited number of studies show that increasing the proportion of natural habitat in the surrounding landscape can buffer the effects of farm pesticide use on wild bee abundance and species richness. Park et al. (2015 observed pesticide effects on a wild bee community visiting an apple (Malus domestica) orchard were buffered by increasing proportion of natural habitat in the surrounding landscape. Bee communities on more intensive farms in areas with little semi-natural habitat in the surrounding local landscape were less abundant and diverse with a corresponding lowering of visitation to crop flowers (blueberry) compared to areas with abundant natural cover in the landscape (Nicholson et al., 2017).
- The interaction between pesticide load and semi-natural habitat is likely to produce complex responses according to taxonomic identity of the organism. For instance, wild bees, true bugs and ground beetles had stronger responses (community homogenisation) to habitat fragmentation at high pesticide loads, whereas for plants and spiders landscape structure was less influential at high pesticide levels (Dormann et al., 2007).
- Non-cultivated plants in agricultural landscapes are a major source of floral resources for bees (Requier et al., 2014). Contamination of pollen from these non-crop sources by multiple pesticide residues appears to be widespread and common (Botías et al., 2015; Long and Krupke, 2016; McArt et al., 2017). This suggests a potential pathway of pesticide exposure to pollinators from spillover or soil contamination of adjacent non-crop habitat (perennial or established annually).

Knowledge gaps: In terms of current knowledge gaps, participants offered the following suggestions:

- Does the interplay between pesticide use in fields and the presence of adjacent field margin habitats affects pollinator diversity, abundance, species interactions and plant pollination?
- Does ecological infrastructure on farms mitigate the effects of pesticide exposure in field?
- Was evidence exists on whether the volume of nectar and pollen produced in planted pollen and nectar strips counters harm to pollinators from pesticides? In other words, does the toxicity of field margins and hedgerows out-weigh the benefits to pollinators from the pollen and nectar supplied?
- Despite the impact of neonicotinoids, do flower rich crop margins continue to provide a net benefit to wild pollinator populations?
- How much semi-natural habitat is required to achieve this, or what level of floral resource diversity in space or time can lower the risk from foraging on pesticide treated crops?
- Is there a minimum distance that flower strips and hedges should have to the field that results in damages through drift?
- What are the effects of flower strips and hedges on the population dynamics of pollinators? So far, most studies only investigate the presence of pollinators in the structures and the surrounding, but this tells us mostly something about the attractiveness of these structures for pollinators, but not whether they really result in a population growth. Pesticides or other agricultural practices could still cause negative effects that overall lead to neutral or even negative effects. In my opinion, new methods or at least longer observation time spans would be necessary.

- To what extent does pesticide-use in conventionally managed fields lower the efficacy of on-farm semi-natural habitats or ecological restoration measures (hedgerow, sown flower margins) that aim to support populations or diversity of pollinators?
- What are the impacts of insecticide sprays on field margins?
- What would be the potential for applying pharmacological principles to predict pesticide sub-lethal toxicity and so, inform environmental safety?
- What are the consequences to insect pollinators of their chronic exposure to individual pesticides via field margins?
- What is the potential for additive/synergistic cocktail effects by the exposure to multiple chemicals via field margin exposure?

Suggestions for next steps:

- Target resources towards restoring large areas of flower-rich habitats that are capable of supplying food resources to solitary, especially oligolectic, bees; that can also provide nesting habitat and undisturbed soil faunas; and that have central areas that provide some refuge from the higher levels of pesticide contamination found in field margins.
- Collaboration with the International Union of Basic and Clinical Pharmacology to assess the hazard/risk of chemical exposure from field margins within the EU.
- To convene a small expert group that could rapidly assess the literature that can provide insight to this question and qualitatively rate the likelihood of harm, form hypotheses to be tested, and scope research themes and/or approaches that are relevant to informing policymaking.

Appendix 1: Full responses from participants

Practical experiences:

Member: Vivien von Königslöw

Date: 17.06.2019 13:36 (GMT)

In my PhD I investigate flower strips and hedgerows adjacent to IP-apple orchards, thus a system with high use of pesticide. In my experience, bees and hover flies use these structures in high numbers when they are in flower. The key issues are the availability, quantity and quality of floral resources. My experimental sites are all situated in IP-orchards. So, unfortunately I cannot compare my results directly to organic orchards. However, the intensity of pesticide use is quite divers in the different orchards. I tested whether the application of B1-pesticides (which were used only in around half of the orchards, B1 = classified as harmful for bees), had an effect on the bee abundance, but found no significant effect. So, overall I assume that there probably is an effect of pesticide application on pollinators in conservation measures, but it is not super high. I think that these structures still result in a net benefit in pollinator populations, because if no such structures were available there would be hardly any pollinators around.

Member: Vivien von Königslöw

Date: 17.06.2019 13:46 (GMT)

I think major open questions are:

- Is there a minimum distance that flower strips and hedges should have to the field that results in damages through drift?

- Which effect do flower strips and hedges on the population dynamics of pollinators? So far, most studies only investigate the presence of pollinators in the structures and the surrounding, but this tells us mostly something about the attractiveness of these structures for pollinators, but not whether they really result in a population growth. Pesticides or other agricultural practices could still cause negative effects that overall lead to neutral or even negative effects. In my opinion, new methods or at least longer observation time spans would be necessary.

Member: ARISTIDIS PARASKEVAS

Date: 18.06.2019 07:43 (GMT)

You are informed that in Piraeus city we don't use chemical pesticide for plant protection.

The use of chemical pesticide in the urban environment is prohibited in accordance with existing legislation.

Conserning the use of fertilizers, we prefer the organic ones.

Conceptual papers:

Member: Chris Connolly

Date: 19.06.2019 13:39 (GMT)

IUPHAR/ISC resource:

There is global concern that the industrial scale use of pesticides, used to maintain intensive agriculture, is deleterious to the environment, may compromise food and water security and compromise populations of insect pollinators; a system of pestidovigilance (Milner 2017) was proposed, comparable to the testing of pharmaceuticals.

Acute toxicity risk to beneficial insect species is assessed using the LD50. However, the impact of non-lethal chronic exposure is difficult due to the high cost of generating statistically significant evidence in the field, with its multiple variables (eg. weather, environment quality and other chemicals present). The identification of exposure concentration or LD50 doses are of limited value where non-lethal effects impact pollinator performance or reproduction. More relevant, is to adopt the principles behind the clinical dosing regimen to achieve safe therapeutic activity in patients where exposure dose/ frequency, its level of absorption and distribution in vivo, its clearance rate and its bioactivity (EC50), the selectivity between its target site (eg. in pest species) and other sites (eg. in pollinators) and it's contraindications (eg. potential interactions with other chemicals or diseases).

We propose the application of these pharmacological principles to predict pesticide sub-lethal toxicity and so, inform environmental safety. For pesticide exposure, the total dose/concentration would be defined as the steady-state levels detected within pollinators after exposure to field-relevant levels (eg. Moffat 2015). When related to the bioactivity of the chemical within the pollinator species under study, this approach would provide a quantitative assessment of risk and informs on the level of mitigation required to reduce pesticide exposure to sub-threshold steady-state levels in beneficial species (eg. by the reduction of dose/frequency/duration of application/co-application with other chemicals).

We (International Union of Basic and Clinical Pharmacology [IUPHAR]) have established specialist databases on drug targets (eg. guidetopharmacology.org) built by collaboration between academia and industries and this infrastructure could be extended to catalogue the effects of pesticides in insect (pest and beneficial) species, as the target sites and chemicals are similar. These databases can include knowledge on pesticide interactions, as we do for drug contraindications, that are essential in assessing risks that may arise from exposure to multiple chemical/disease hazards. Furthermore, knowledge on adaptive processes in vivo, such as increased vulnerability to future exposure (Moffat 2016) or preference seeking in honeybees (Kessler 2015). This becomes highly relevant when we consider that the risk from chronic exposure via chemically contaminated field margins is relatively unknown.

Support for unexpected chronic exposure hazard comes from several large-scale DEFRA and industry studies which inadvertently identified a background neonicotinoid contamination of control sites (eg. Thompson 2013), where the chemicals have not been used recently. These findings have been supported by a direct analysis of local wildflowers where it was demonstrated that 97% of neonicotinoid exposure to honeybees was not from flowering crops, but wildflowers (Botias 2015, 2016). Indeed, neonicotinoids have been detected also in the soil (Jones 2014) and local dandelions (Krupke 2012).

Importantly, this alternative exposure route is prolonged throughout the flowering season and so delivers a constant chronic dose of neonicotinoids (and other unknown chemicals). Therefore, this alternative route of exposure likely contributes to the global presence (up to 80% of samples tested) of neonicotinoids in honey sold for human consumption (commentary in Connolly 2017) and likely contributes to the hundreds of pesticides found within honeybee hives (Mullin 2010). Therefore, there is a considerable knowledge gap on the consequences to insect pollinators of their chronic exposure to individual pesticides via field margins. Moreover, the potential for additive/synergistic cocktail effects by the exposure to multiple chemicals via field margin exposure is unknown. This identifies a major confounding factor that compromises the use of field margins to enhance local ecosystems by the provision of native forage to key crop pollinators. Such practices may compound the threat to insect pollinators.

We propose a unique role for the IUPHAR, which is linked to the International Science Council (ISC), in providing access to thousands of expert cellular scientists and expert pharmacological curators of chemical databases to build an open access database of existing knowledge and to initiate key bioactivity studies (eg. ligand-binding assays on tissue from pollinator species) to fill key knowledge gaps on possible chemical hazards. This would form part of IUPHAR's existing databases (guidetopharmacology.org, guidetoimmunopharmacology.org, guidetomalariapharmacology.org), which is quality controlled by 90 expert subcommittees of ~800 scientists.

To aid in the understanding of our basic pharmacovigilance concept, we describe the environment as the patient and the target is the pest species (Figure 1 [could not include]). A chronic health risk is the damage to non-target sites (eg. pollinators) that may result from an imbalance between exposure and clearance rates, with the impact being compounded by molecular adaptations (eg. environmental adaptations – pest species resistance against the drug (pesticide) (Wu 2018), increased sensitivity [Moffat 2016] and preference seeking in honeybees {Kessler 2015]).

'Environmental pharmacology' deals currently with the entry of chemicals or drugs into the environment after elimination from humans and animals. However, there is a much more fundamental role for the adoption of pharmacological principles in the design and monitoring of safety for pesticides released directly into the environment. The quantitative values possible by the application of environmental pharmacology, would enable this science base to move beyond the impact to single bees by integrating into environmental models of bee colony performance (eg. BEEHAVE, http://beehave-model.net/). Furthermore, pesticides act at distinct sites which are frequently those already established for human health (e.g. nicotinic receptors, or enzymes) where expert subcommittees already exist, and where it would be trivial to add experts on the equivalent insect receptors.

Figure 1. The relationship between the clinical assessment of therapeutic dosing and the sub-lethal impact of pesticides to beneficial species. The host is either the patient or the environment, with the threat being either a disease (in man) or a pest species (in the environment). Delivery of the effective drug (man) or

pesticide (environment) requires that a bioactive steady-state dose is achieved by the dosing regimen (concentration or frequency of dosing) but this does must be at a level below that causing toxicity from side-effects where the drug/pesticide can now act at off-target sites such as another organ (man) or a beneficial species (environment). However, chronic use needs to also consider where potential adaptations (eg. addiction/sensitisation in man or preference seeking/sensitisation in pollinators) may occur. Finally, there is a growing concern about the number of medications elderly patients take (called polypharmacy, (Tatonetti 2012)) where complex contraindications may occur in man. In contrast, the situation for the environment, where unknown chemical cocktails exist, its 'off-target' effects (eg. on pollinators and man) are not yet fully realised, from the perspective of the long-term health of the ecosystem and man.

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Previous Research Track Record of IUPHAR

The IUPHAR is a unique worldwide academic and industrial group addressing clinical and preclinical pharmacology. The Nomenclature Committee (NC-IUPHAR) has set up the IUPHAR/BPS Guide to PHARMACOLOGY database (GtoPdb), based in Edinburgh, with joint funding from IUPHAR and The British Pharmacological Society (BPS) and Wellcome Trust – supported by a federate of >80 drug target subcommittees, representing ~800 expert pharmacologists worldwide, allowing an independent academic/industrial expert-driven system of data collation and giving recommendations on key pharmacological interactions. This has now been extended with a collaboration with the International Union of Immunological Sciences (IUIS), and the Guide to Medicines for Malaria with the Medicines for Malaria Venture (MMV, funded by Bill Gates).

NC-IUPHAR was set up 30 years ago to resolve controversial issues in receptor pharmacology and nomenclature with an expert-driven approach, as the data are too complex for a 'data-trawling' approach. NC-IUPHAR has three outputs: articles with recommendations, GtoPdb, and specific symposia to address key issues. The management structure of having core committee meetings twice yearly, with specific delegation/communication to multiple expert subcommittees and follow-up via detailed minutes, has proven to be both successful and sustainable. This allows public-spirited lead scientists to ensure that their research areas are scientifically 'clean' with appropriate nomenclature and defined proteins. Recent efforts have included defining the main experimental variables and clinical translatability in a given field. Only validated and reproduced data are used, and because of this, uniquely, both academic and industrial scientists work in harmony in subcommittees and the core committee. Thus, this may be the only way to generate a way forward between industry and environmental protection.

Thus, 125 IUPHAR publications have an h-index of >80 – the databases are visited by scientists from 160 countries, and many biotechs. Thus, this management structure could be extended to the urgent, complicated and contentious area of environmental pharmacology. In this respect, we have already made simple recommendations to the House of Commons subcommittee about the molecular targets and synergies between pesticides, in the honeybee debate and have support.

We hope that the EKLIPSE network finds this approach will highlight key knowledge gaps and provide unique expertise to collaborate with other members of the network to assess the hazard/risk of chemical exposure from field margins within the EU.

Yours Sincerely

Michael Spedding (Secretary General)

Christopher N. Connolly

International Union of Basic and Clinical Pharmacology (IUPHAR)

Modelling studies: no input

Empirical studies:

Member: Juliette Young

Date: 21.05.2019

Please add here any empirical studies you may know of that could inform the call. Here are a few suggested by Lynn Dicks in the call for knowledge:

Botías, C., David, A., Hill, E.M., Goulson, D., 2016. Contamination of wild plants near neonicotinoid seed-treated crops, and implications for non-target insects. Sci Total Environ 566-567, 269-278.

Botías, C., David, A., Horwood, J., Abdul-Sada, A., Nicholls, E., Hill, E., Goulson, D., 2015. Neonicotinoid Residues in Wildflowers, a Potential Route of Chronic Exposure for Bees. Environmental Science & Technology 49, 12731-12740.

David, A., Botias, C., Abdul-Sada, A., Nicholls, E., Rotheray, E.L., Hill, E.M., Goulson, D., 2016. Widespread contamination of wildflower and bee-collected pollen with complex mixtures of neonicotinoids and fungicides commonly applied to crops. Environ. Int. 88, 169-178.

Member: Matt Shardlow

Date: 22.05.2019 12:05 (GMT)

A recent American study - Mogren and Lundgren 2016 - it found that the pollen and nectar in flowers in pollinator strips adjacent to crops were so polluted with neonicotinoids that they caused harm to Honeybees and that the concentrations of neonics in bee bread were eye wateringly high, well above the levels that could stop wild bees from reproducing successfully (e.g. Whitehorn et al. 2012). While Mogren and Lundgren 2016 report that exposure of bees to neonics was much higher close to neonic treated crops, even wildflower strips 150 metres away from treated crops caused significant exposure to the Honeybees. The most important caveat is, of course, that this study was in the US where treatment rates and frequency may be more intense than in the EU.

Planted crop margins do provide lots of great resources for bumblebees, butterflies and other insects (Pywell et al. 2011, Carvell et al. 2005, Carvell et al. 2006, Blake et al. 2011, Thomas and Marshall 1999, Haaland et al. 2011). Although caution is required in drawing conclusions about the population effects of flower resources from foraging activity data, for instance Holzschuh et al. 2016 found that despite certain pollinators feeding on mass flowering crops, it did not follow that at a landscape scale their populations benefitted.

The risk to field margin ecology from pesticides used on adjacent crops has long been recognised, in 2002 Marshall and Moonen said "*Their close proximity to agricultural operations renders them susceptible to disturbance, particularly from pesticide drift and eutrophication*". Even the pesticide industry's own report on crop field margins (Hackett and Lawrence 2014) acknowledges that pesticide contamination could harm life in the field margins. "*Field margins can also separate the cropped area from hedgerows or other off-crop features (including other cropped areas) thus reducing levels of spray drift of pesticides. However, to reduce spray drift to a hedgerow the field margin intercepts the pesticide and may be impacted. The level of impact caused by spray drift will then depend on whether a species occupies the field margin or hedgerow alone*." and it is known that water transfer can move pesticides up to 20 meters across field margins "*the CORPEN9 review, and the guidance produced, which recommends buffer width of between 10 m to 20 m for 70 to 80 % reduction efficiency of pesticides*." .

Despite the clear risk to crop margin habitat strips from pesticide sprays there not many papers quantifying the impacts of insecticide sprays on field margins, and none on bees that we can find! However, Bundschuh et al. 2012 found that only field margins wider than nine metres supported grasshoppers and put this down to pesticide drift; Langhof et al. 2009 estimated that pesticide drift three metres into a margin would cause <30% [!] mortality of a parasitic wasp and ≤52% mortality of seven spot ladybirds; and Hahn et al. 2015 found that pyrethroid insecticide sprays significantly reduced the abundance of caterpillars and moths in crop field margins.

The paucity of evidence relating to insecticide sprays and pollinators in field margins is unfortunate considering that pyrethroids in particular are known to impact on beneficial invertebrates (Ewald et al. 2016) and their use is very high – almost universal on arable land – and increasing (Underwood and Mole 2016). We really should by now have properly ascertained the risk to pollinators from sprays drift onto field margins, thankfully there is more information about the movement of neonicotinoid seed treatments into margins and the levels of exposure that create lethal and sub-lethal harm to pollinators.

So do we know if neonic levels in EU planted crop margins were so high that their toxicity out-weighed the benefits to pollinators from the pollen and nectar supplied?

The levels of neonics found in the USA field margin study are high, but high levels have also been found in field margins in the EU. In particular Botias et al. 2015 (and Botias et al. 2016) found higher levels of neonics in wildflowers in margins than in adjacent Oilseed rape crops, including one plant with a very high concentration indeed, the study also found that 97% of Honeybee neonic exposure was via wildflowers, with only 3% via the crops.

The findings of higher levels of neonics in wildflowers than in the adjacent crop is not unusual and was also found by Stewart et al. 2014 and Rundlof et al. 2015. These studies focus on concentrations in wildflowers which may not be representative of the concentrations that occur in plants in planted crop margins, however Botias et al. 2015 did find high concentrations in *Vicia* and *Trifolium* and Stewart et al. 2014 also included these genera commonly in their analysis; so plants commonly grown in pollinator strips are definitely capable of transmitting harmful levels of neonics to pollinators. Different types of plants take up, concentrate or accumulate neonics differently. We know for instance that crops show different preferential absorption of neonicotinoids and take them up to different extents Sur and Stork 2003, so some wildflowers may be more prone to concentrating neonicotinoids than some crops.

I have had a previous discussion with Christina Botias about this possible phenomenon and she said "We didn´t find a very clear trend of a specific plant or plant types (woody vs herbaceous, perennial vs annual) to be more likely contaminated. We detected clothianidin at significantly higher concentrations in annual plants vs. perennials, but then imidacloprid was present at higher concentrations in perennials. Also imidacloprid was at higher levels in herbaceous vs wood plants."

Of course there are lots of other studies that detected high levels of neonics in pollen and nectar in field margin plants, including Greatti et al. 2006, Krupke et al. 2012, Pettis et al. 2013 (data), David et al. 2016 and Mortl et al. 2018.

In the absence of a tenable theory why they would be less polluted, in my view there is no reason not to suppose that plants in crop margins would have been just as polluted as other wildflowers growing in similarly highly exposed situations.

It may be thought that most of the contamination of wildflowers adjacent to crops was via the movement of soil water, but dust probably also played a key role in exposing plants and pollinators near crops to dangerous levels of neonics. Dust emitted during the planting of neonic treated seeds contained very high concentration of neonicotinoids Girolami et al. 2011, the dust landed directly on wildflower leaves where it could be readily absorbed, a leaf presents a much larger and more permeable surface area than a seed.

Neonicotinoids appear to concentrate in the soil surface, and when the field is bare toxic dust can blow between fields Limay-Rios et al. 2015, affecting large areas (Krupke et al. 2017) and indeed for distances over 250 m Forero et al 2017 – so plants growing in margins when field is bare were/are vulnerable to additional contamination from neonics concentrated in such dust.

We know from Woodcock et al. 2016 that 40% of the wild bees they studied had disappeared from at least 10% of their UK distribution as a direct result of neonicotinoid use. Neonics were not simply reducing wild bee abundance; the effect was so strong that they also caused bee species to entirely disappear from large parts of their former range. Figure 2 in Woodcock et al. 2016 shows that the negative shift on 2a due to neonicotinoid exposure for Oilseed rape (OSR) foraging bees is considerably greater than the positive shift for OSR-feeders associated with increased area of OSR in 2b and the negative shift in 2a for non-OSR-feeding bees is additive to the negative shift in 2b. Therefore, there were marked negative impacts from OSR+neonics on both groups of bees. But, how much of the neonicotinoid exposure arose from feeding on Oilseed rape, as assumed in Woodcock et al. 2016, and how much arose from contaminated wildflowers? We do not have a conclusive answer to this, while Botias et al. 2015 found that 97% of the exposure was from wild flowers, other studies recorded higher proportions of pollen and nectar being gathered from the crop. On the other hand, many of the studies only focussed on the exposure of the bees while Oilseed rape was in flower and hence ignored exposure from adjacent wildflowers during the rest of the year. We will probably never know the balance of contamination exactly, but most recent research suggests that contamination from non-crop flowers was in the same ball park as crop mediated contamination (Botias et al. 2015 (10% of pollen from OSR), Tsvetkov et al. 2017, Garbuzov et al. 2015, Long and Krupke 2016). David et al. 2016 is particularly helpful here, they found that pollen from OSR contained 166 ng/g of pesticide, compared with from 78 and 25 ng/g for wildflowers sampled from OSR and Winter wheat margins respectively. However, in Honeybee collected pollen they found 17 ng/g during OSR flowering and 2.6 ng/g after. While there is little doubt that contamination levels during the 3 or 4 weeks of OSR flowering was higher than the contamination at other times, contamination from wildflowers occurred over six to eight times the time period, so I suspect that in in practice the annual dose from each source – crop and wildflowers - was often similar.

Another study gives us some additional insight; Tsvetkov et al. 2017 studied the exposure of bees in a system in Canada where there were no crops regularly visited by bees, so almost all the exposure must have come from wildflowers. They found levels of contamination that caused significant harm to Honeybee health, showing again that neonics do not need a crop vector to cause harm to pollinators.

I think it is an unavoidable conclusion that neonicotinoid contamination from crop margins has the potential to harm bees, but is there evidence that the volume of nectar and pollen produced in planted pollen and nectar strips countered this harm to pollinators? Despite their pollution with neonicotinoids, did flower rich crop margins continue to provide a net benefit to wild pollinator populations?

Direct evidence showing benefits of particular flower-rich habitats to pollinator populations is rare due to the difficulties of measuring this. It is one thing to record if pollinators are using a pollinator margin, but it is a much harder task to examine whether this is having a population level positive effect.

Key studies such as Wood et al. 2016 – that showed that planted crop margins provide food resources for bumblebees and Honeybees, but are a lot less helpful to solitary bees – rely on counting visits by bees and analysing their pollen loads. Unfortunately this is not data that helps us to prove that the margins are having a positive effect at a population level.

One of the few studies to look at actual populations of bees at a landscape scale during the height of the neonicotinoid contamination period was the CEH study on the Hillesden Estate (Carvell et al. 2017 and Redhead et al. 2016). This study used advanced molecular techniques coupled with detailed surveys of floral resources to show a greater residence time of bumblebee family lineages (and therefore benefits to the population) in arable landscapes where flower-rich habitats had been sown compared with arable landscapes depauperate in floral resources. This study was conducted across the 1000ha Hillesden experimental farm in 2011-2012, while the farm was using neonicotinoid seed dressings on its Oilseed rape and wheat. The study was also coincident with the very widespread use of neonicotinoids in these crops elsewhere in the landscape. So we can infer that despite the use of neonicotinoids, the provision of floral resources appeared to benefit bumblebee populations. At Hillesden the majority of the floral habitats were perennial wildflowers (by area) but there were also patches of annual wild bird seed. However, what we do not know from this study is whether the benefits of floral resources would have been greater if neonicotinoids had not been used on the farm and wider landscape, nor is it possible to split apart the comparative effects of restored meadows, versus arable margins (Claire Carvell pers. com.), because the data is lumped, one habitats could be providing a benefit and the other harm and still give a net positive result – particularly as planted crop margins were a minor component of the provided floral resources (only 2% of total area).

Recent evidence Powney et al 2019 gives us some improved confidence that even at the height of the use of neonics the creation of flower rich field margins may have continued to provide significant benefit to some pollinator species. The data shows that, in contrast to other bees and hoverflies, eusocial species (primarily bumblebees and honey bees) maintained their distribution between 2002-2013. These species have a big overlap with those that we know benefit from flower rich habitats on arable margins. So something appears to have been sustaining their populations while other species were hit hard by neonics, and it may well have been field margins in agri-env schemes that enabled this to happen. Although we should remember that only <0.2% of England is in flower rich margins and other factors could be responsible for eusocial species doing better than solitary bees.

Neonicotinoids have now been comparatively well studied, so we have more knowledge about their persistence, dispersal and action in the environment than we do about most pesticides. However, the three neonics that are subject to the 2018 ban are not the only chemicals we need to consider when thinking about the potential for pesticides to harm bees. In the USA a link has been found between Chlorothalonil and bumblebee declines McArt et al. 2017. From a domestic perspective, although it is due to be phased out in 2020, in 2016 Chlorothalonil was the most widely-used individual active substance and in terms of weight applied, the principal formulation used in the UK Fera 2018. In addition there are other persistent insecticides now coming into use such as Cyantraniliprole and even new neonicotinoids such as Sulfoxaflor are awaiting approval. To date the 2013 EFSA bee risk assessment process is being blocked by the EU Member States, in the absence of any new measures to prevent future pesticides from causing a recurrence of the harm caused to bees and pollinators by neonics we have to assume that this will recur, and may even be worse next time.

So to summarise the evidence; neonics in the landscape harmed bee populations (and probably also populations of birds Hallmann et al. 2014, butterflies Gilburn et al. 2015 and other animals Douglas et al. 2015) and a significant proportion of this harm arrived through flowers growing adjacent to and within 150 metres of treated crops. In some cases harm was observed in landscapes where none of the contamination would have come through the pollen and nectar of a crop. There is good evidence that before neonics the pollen and nectar boost provided by planted crop margins assisted bumblebee populations and Honeybees. There is evidence that these eusocial bees were less impacted by neonicotinoids than other bees, but it remains unclear if the harm caused by the accumulating levels of neonicotinoids entering these and many other pollinator species through the crop margins negated the benefit that was previously provided. It is not clear if the most polluted crop margins were causing net harm, although it seems likely, or if there were sufficient less polluted crop margins that counteracted this and ensure that such agri-environment schemes therefore continued to provide a net benefit to pollinator populations, although this seems likely for eusocial bees. Of course bees are not the only beneficial or conservation significant species of invertebrate that may benefit from well managed field margins, but we have practically no information about the impacts of neonicotinoids in field margins on hoverflies, ground beetles, lacewings, ladybirds, butterflies or moths.

It is tempting to breathe a sigh of relief and think that thankfully now the three most persistent neonicotinoids have been banned crop margins will again provide a clear benefit. But what of Chlorothalonil, Cyantraniliprole, Sulfoxaflor and pesticides still in the pipeline – could they cause similar or worse harm? – no-one has done the science so we do not know. In addition pyrethroid spray drift may also impact on bees using field margins (as it does with moths), but this is yet to be quantified. Until the pesticide testing regime is improved to include independently run testing of the persistence, fate and impacts of such chemicals on wild bees – before they are approved for use – planted crop margins remain vulnerable to becoming part of a poison delivery mechanism to bees and other pollinators.

Society wants public investment to restore wildflowers to the countryside but we must be mindful of the potential for pesticide contamination to reduce the value of this investment. So we do not put all our eggs in one basket, and as we cannot yet be confident that plants growing close to crops will not be toxic to pollinators, it may be wise to also target resources towards restoring large areas of flower-rich habitats that are capable of supplying food resources to solitary, especially oligolectic, bees; that can also provide nesting habitat and undisturbed soil faunas; and that have central areas that provide some refuge from the higher levels of pesticide contamination found in field margins.

Member: Adam VANBERGEN

Date: 13.06.2019 12:00 (GMT)

Semi-natural habitats benefit pollinators that can support pollination services to wild plants and crops. There is some published evidence of widespread pesticide contamination of non-crop flowers and fewer studies indicating that landscape-scale semi-natural habitat may mitigate effects of conventional intensive agriculture (including pesticide use) on pollinators to a certain degree. Below I detail some key points:

• Land-use change, conventional agricultural management and pesticide use represent a major risk to pollinators and pollination, but agricultural management more sympathetic to beneficial biodiversity can be part of the solution (IPBES, 2016; Kovács-Hostyánszki et al., 2017; Potts et al., 2016).

• Conclusions of a global meta-analysis (Kennedy et al., 2013) on local and landscape effects on wild bee pollinators were that farm-scale simplification of fields (monoculture) increases the importance of the quantity and diversity of semi-natural in the surrounding landscape. Conversely, field diversification lowers this reliance on landscape quality for bees.

• There is evidence of positive relationships between native bee richness, abundance and flower visitation and landscape-scale semi-natural habitat and negative relationships with agricultural management intensity (including pesticide use or proxies thereof) (Kennedy et al., 2013; Nicholson et al., 2017). There are links between semi-natural habitat, ecological restoration, pollinator visitation and diversity and pollination of crops and wild plants (Garibaldi et al., 2016; IPBES, 2016; Kovács-Hostyánszki et al., 2017; Pywell et al., 2015).

• There is also evidence that organic farms (with low or no pesticide use) tend to support greater local numbers and richness of foraging insect pollinators, and some evidence that it can benefit pollination, although this effect tends to be reduced in already diverse, heterogeneous landscapes (IPBES, 2016; Kennedy et al., 2013).

• On-farm semi-natural habitats, such as hedgerows and sown flower margins, provide food and nesting resources for insects, including pollinators and natural pest control agents, increasing their activity, and with emerging evidence of population benefits (Carvell et al., 2017; Haenke et al., 2014; Jha and Kremen, 2013; Kremen et al., 2018; Ponisio et al., 2016).

• A limited number of studies show that increasing the proportion of natural habitat in the surrounding landscape can buffer the effects of farm pesticide use on wild bee abundance and species richness. Park et al. (2015 observed pesticide effects on a wild bee community visiting an apple (Malus domestica) orchard were buffered by increasing proportion of natural habitat in the surrounding landscape. Bee communities on more intensive farms in areas with little semi-natural habitat in the surrounding local landscape were less abundant and diverse with a corresponding lowering of visitation to crop flowers (blueberry) compared to areas with abundant natural cover in the landscape (Nicholson et al., 2017).

• The interaction between pesticide load and semi-natural habitat is likely to produce complex responses according to taxonomic identity of the organism. For instance, wild bees, true bugs and ground beetles had stronger responses (community homogenisation) to habitat fragmentation at high pesticide loads, whereas for plants and spiders landscape structure was less influential at high pesticide levels (Dormann et al., 2007).

• Non-cultivated plants in agricultural landscapes are a major source of floral resources for bees (Requier et al., 2014). Contamination of pollen from these non-crop sources by multiple pesticide residues appears to be widespread and common (Botías et al., 2015; Long and Krupke, 2016; McArt et al., 2017). This suggests a potential pathway of pesticide exposure to pollinators from spillover or soil contamination of adjacent non-crop habitat (perennial or established annually).

• There appears, however, to be a dearth of empirical knowledge about whether an interplay between pesticide use in fields and the presence of adjacent field margin habitats affects pollinator diversity, abundance, species interactions and plant pollination. We do not know if providing ecological infrastructure on farms can mitigate the effects of pesticide exposure in fields. Moreover, how much semi-natural habitat is required to achieve this, or what level of floral resource diversity in space or time can lower the risk from foraging on pesticide treated crops? Equally, the extent that pesticide-use in conventionally managed fields lowers the efficacy of on-farm semi-natural habitats or ecological restoration measures (hedgerow, sown flower margins) that aim to support populations or diversity of pollinators is not established.

• One way for EKLIPSE to address the issue of whether there is an effect on pollinators and pollination from an interaction between pesticide use and ecological infrastructure would be to convene a small expert group. They could rapidly assess the literature that can provide insight to this question and qualitatively rate the likelihood of harm, form hypotheses to be tested, and scope research themes and/or approaches that are relevant to informing policymaking.

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Member: Lotta Kaila

Date: 15.06.2019 14:51 (GMT)

In Finland we are studying pesticide residue levels and their effects on honey bees and natural pollinators in Finnish agriculture (filed conditions) when the pesticide application is compliant. Compliant application means following the instructions given by the authority (Finnish Safety and Chemicals Agency Tukes).

The results of the study provide information about the pesticide exposure levels of pollinators in Finnish agriculture. Moreover, the results enhance understanding on the effects of the residues on wild pollinators in boreal farmland. These results will help to estimate whether the current pollinator protection measures in Finland are adequate.

Literature reviews:

Member: Zoolab Torino DBios-UNITO

Date: 20.06.2019 21:00 (GMT)

Good evening, we are a research group from Turin, we study in particular butterflies.

We can suggest this paper that could be useful for general knowledge related to the management of agricultural environmental.

Review: How effective are European agri-environmental schemes in conserving and promoting biodiversity? Kleijn and Sutherland 2003

Oliver and Morecroft (2014) Interactions between climate change and land use change on biodiversity: attribution, problems , risks and opportunities. WIREs Climate Change

Konvicka et al. (2008). How too much care kill species: grassland reserves, agri-environemntal schemes and extinction of Colias myrmidone (Lepidoptera: Pieridae) from its former strognhold. J Insect Conserv 12: 519-525

Directive 2009/128/EC on sustainable use of pesticides 01/2014

Appendix 2: References suggested by KNOCK Forum participants

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