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**Towards an integrated environmental risk assessment of multiple stressors on bees: review of research projects in Europe, knowledge gaps and recommendations**

Abstract

This report reviews recent work on bee health carried out by EFSA, Member States (MSs) and the European Commission (EC). It identifies data and knowledge gaps and provides research recommendations that may facilitate the transition towards an integrated environmental risk assessment of multiple stressors on bees. The report was produced by the EFSA Bee Task Force (TF), involved representatives from six different Scientific Units, and was coordinated by the Scientific Committee and Emerging Risks Unit (SCER). The TF consulted experts from MSs and the Bee Interservice Group of the EC. Additional scientific exchanges with experts were promoted by SCER through the organisation of a scientific colloquium on bee health in May 2013. The review identified a total of 220 research projects on bee health at EU level (EFSA, 19; MSs, 181; EC, 20), and 33 additional projects from other international organisations dealing with general aspects, non-research-focused, of bee issues. A quantitative assessment of the retrieved projects revealed that research projects on multiple stressors on bees and projects on bees other than honeybees were missing, especially with regard to monitoring and testing. EFSA projects were predominantly in the area of risk assessments of pesticides on bees. Research projects on in-hive treatments and bee exposure to chemicals funded at the EC level were scarce, as were those focusing on protection goals, bee diversity and pollination services at the MS level. The qualitative assessment of the retrieved projects revealed knowledge gaps at each step of the risk assessment, which led to several recommendations for future scientific work at EFSA and research to be undertaken in the framework of Horizon 2020. Additional recommendations are given for research coordination, planning and knowledge sharing with MSs and the EC. At EFSA level, further communication, internal collaborations and training on bee health are suggested.

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Summary

In accordance with the strategy of the European Food Safety Authority (EFSA) to consider risk assessments in a wider integrated manner, the Scientific Committee and Emerging Risks (SCER) Unit set up an internal Bee Task Force (TF) to review the work carried out by EFSA, Member States (MSs) and the European Commission (EC) in the area of bee health, and to identify knowledge gaps and provide recommendations facilitating the transition towards an integrated environmental risk assessment of multiple stressors on bees.

The EFSA Bee TF was composed of (scientific) officers from four EFSA Directorates (i.e. the Science Strategy and Coordination, the Scientific Evaluation of Regulated Products, the Risk Assessment and Scientific Assistance and the Communications Directorates) and six scientific EFSA Units (SCER, Animal Health and Welfare, Genetically Modified Organisms, Pesticides, Plant Health and Scientific Assessment Support Units). The multi-disciplinary composition of the Bee TF fostered an open dialogue on risk assessment approaches between Units and exchanges of information across scientific fields. This enabled the reinforcement of internal collaborations and the use of internal scientific expertise in the area of bee health.

To review research work produced in the area of bee health, the Bee TF scrutinised its own work and conducted a series of consultations with MSs and the EC in 2012/13, in order to collect information on recent and ongoing research on bees. For MSs, information was requested through several networks of experts: the internal EFSA networks, Panels and Focal points and the international network Honeybee Colony Losses (COLOSS). To collect information from the EC, the Bee TF liaised with the EC Bee Interservice, which is composed of the five Directorates General (DGs) involved in bee issues (i.e. Agriculture and Rural Development (DG AGRI), Enterprise and Industry (DG-ENTR), Environment (DG ENV), Research and Innovation (DG RTD), and Health and Consumers (DG SANCO)). In addition, the SCER Unit organised a scientific colloquium on risk assessments of multiple stressors on bees in May 2013, in order to discuss and gather views from a wide range of stakeholders. Finally, to complete this inventory, the Bee TF compiled information related to bee issues mainly from the European Environment Agency (EEA), the European Medicines Agency (EMA), the European and Mediterranean Plant Protection Organization(EPPO), the Food and Agriculture Organization (FAO), the Organisation for Economic Co-operation and Development(OECD), the World Organisation for Animal Health (OIE) and the United Nations for Environmental Programs (UNEP). Most of this information (i.e. guidelines, standards, manuals and/or general facts and communication items on bees) was not analysed by the Bee TF which focused its assessment on research data related to risk assessments of single and multiple stressors on bees.

The review of EFSA’s work led to the identification of 16 published outputs (Appendix A) and three ongoing activities (Appendix B). Consultations with the EC and MSs identified 201 projects, of which 20 were from the EC (Appendix C) and 181 were from MSs (Appendix D). Fifty-seven per cent of these projects were finalised at the time of the completion of the consultation. An additional 33 projects, mainly from EEA, EMA, EPPO, FAO, OECD and UNEP, were retrieved (Appendix E).

The Bee TF performed quantitative and qualitative assessments of the retrieved projects in order to identify data and knowledge gaps, cross-cutting issues in risk assessment and research needs. The data gap analysis was performed by making a quantitative assessment of the projects, which were categorised according to scientific area(s) (eight pre-defined areas), type of bee(s) investigated (i.e. honeybees, bumble bees and/or solitary bees), level of coordination (i.e. EC or MSs), and status in terms of project completion (i.e. still ongoing or completed in June 2013). This assessment was conducted on EFSA scientific outputs and projects retreived from the EC and MSs.

To identify knowledge gaps and research needs for the environmental risk assessment of multiple stressors on bees, the Bee TF also performed a qualitative assessment at each step of the risk assessment scheme. This assessment was conducted mostly on EFSA scientific outputs because the information retrieved from the EC and MSs could not be thoroughly assessed (e.g. most projects were still ongoing with no final or published results).

A pilot bibliometric analysis was conducted on a small set of EFSA scientific outputs in the area of risk assessment of plant protection products (PPPs) for bees. The objective of this analysis was to illustrate the usefulness of such an approach for the identification of experts and missing/required expertise.

The analysis of EFSA scientific outputs revealed that EFSA has initiated work on bee health since 2008 and that, since this date, its involvement and workload in this area has increased continuously, especially in 2013. The EFSA scientific outputs cover seven of the eight pre-defined areas (i.e. no project on in-hive treatments which is an area that does not fall under EFSA’s remit). Most EFSA outputs are on the risk assessment of PPPs on bees and they were mostly produced by the Pesticides Unit. The least covered areas are in the areas of “protection goals/bee diversity/pollination services” and “bee pathogens/pests/predators”. Finally, most of these studies tend to focus on honeybee species (*Apis mellifera* spp.).

The number of projects collected from the EC and MSs was quite large. However, the list was not exhaustive and sometimes the information provided was incomplete or not publicly accessible. Most EC-funded projects (16/20) were received from DG RTD. However, the number of projects funded partly by DG AGRI (and MSs) is underestimated since such projects are mostly reported by MSs. Projects from the EC dealing with in-hive treatments and bee exposure to PPPs are not well represented or are absent, and projects on protection goals/bee diversity/pollination services coordinated by MSs are rare. Overall, whether at the EC or MS level, the number of projects on the risk assessment of multiple stressors on bees was low.

At the EC and MS levels, research on bees other than honeybees (i.e. bumble bees and solitary bees) is generally missing, in particular at the MS level and with regard to the fields of monitoring and testing. In addition, although there is a wide diversity of honeybee subspecies and ecotypes, with specific environmental adaptations, in Europe, research on honeybees usually focused on a few subspecies. Finally, too little research is conducted on honeybee reproduction to provide explanations on the troubles observed by beekeepers on queens and drones (e.g. abnormal laying behaviour and shorter longevity in queens, sterility in drones, etc.).

To consolidate the transition towards an integrated environmental risk assessment of multiple stressors on bees, the Bee TF made a set of recommendations: recommendations for future scientific work to be undertaken by EFSA and the EC (DG RTD) through the framework of Horizon 2020; recommendations on how to tighten coordination and planning of research in Europe and enhance knowledge sharing with MSs and the EC; and finally, recommendations to strengthen communication, promote internal collaborations and to develop training on bee health at EFSA.

For various aspects of the environmental risk assessment, specific recommendations are given, focusing on:

* problem formulation and protection goals for bees and pollination services (e.g. harmonisation of risk assessment approaches to set protection goals, assessment of changes in pollination services with bee diversity);
* monitoring and exposure to bees (e.g. long term EU-wide monitoring of all types of bees; applied research for the development of calibrated tools and validated methods to assess bee mortality, colony development and sublethal effects in bees in field conditions; occurrence data of residues from several classes of chemicals including PPPs, veterinary medicines and contaminants in various matrices relevant for bees such as pollen, bee bread nectar, beeswax, honeydew, water, guttation (etc.); data on foraging and food intakes by honeybees, bumble bees and solitary bees; data on the nutritive value of different pollen types and on the sugar content in nectar; metabolism of xenobiotic in bee midgut; development of single- and multi-residual analysis methods with low limits of detection and quantification);
* hazard identification for different classes of chemicals (and their metabolites), including PPP and contaminants (e.g. dose–response relationships and species sensitivity distributions for bees; toxicokinetics and toxicodynamics for the different chemicals and bee species; toxicity data for bees under different temperature ranges and types of diet; standardised laboratory tests for acute and chronic toxicity of lethal/sublethal endpoints to multiple chemicals and contaminants; standardised laboratory tests for toxicokinetics of single and multiple doses; critical review of behavioural and physiological protocols to assess sublethal and chronic effects in bees; population dynamics-based models to predict effects at the colony level; modelling techniques to extrapolate observations from individual to population level and to test multiple stressors and co-exposures; molecular markers for bees with omic techniques);
* risk assessment (e.g. case studies for risk characterisation, uncertainty analysis using deterministic and probabilistic models for single and multiple stressors; quantitative weight of evidence approach).

To tighten coordination of research in Europe, the Bee TF advocates the establishment of a group of experts or a network composed of the various stakeholders identified in this review (e.g. EFSA, the EC Bee Interservice Group, the European Reference laboratory on bee health, EMA and experts from MSs), in order to develop methodologies for the risk assessment of multiple stressors on bees and, when needed, to develop action plans on new and emerging bee health issues in Europe.

To consolidate forward research planning, the Bee TF recommends that EC-funded projects, which represent a large volume of information, are reviewed to assess those results and findings which could contribute to a better understanding of bee losses and colony weakening, with a particular attention to results dealing with co-exposure, (synergistic and cumulative) interactions of multiple stressors on bees.

Knowledge sharing with MSs and the EC could be enhanced by making EC-funded reports and relevant data publicly available and by developing an open-access bee health database containing relevant scientific information for the risk assessment of single and multiple stressors on bees.

Finally, the Bee TF recommended that the development of horizontal projects on bee health be further explored with the continuation of internal collaborations and communications across Units on this topic. It is also suggested increasing external communications with MSs and the EC, on EFSA’s work on bee health, through regular liaison with the EFSA Advisory Forum and the Bee Interservice Group on the progress made by EFSA on this topic.

Keywords

Environmental risk assessment, bee health, honeybee, bumble bee, solitary bee, knowledge gap

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**See also**

* [News story: Call for European research network to address bee losses](http://www.efsa.europa.eu/en/press/news/140313.htm?wtrl=01)
* [Environmental Risk Assessment homepage](http://www.efsa.europa.eu/en/topics/topic/era.htm?wtrl=01)
* [Bee health homepage](http://www.efsa.europa.eu/en/topics/topic/beehealth.htm?wtrl=01)
* [Scientific Committee and Emerging Risks Unit](http://www.efsa.europa.eu/en/panels/scer.htm?wtrl=01)
* [Mandate](http://registerofquestions.efsa.europa.eu/roqFrontend/questionLoader?question=EFSA-Q-2012-00531)
* [EFSA Journal](http://www.efsa.europa.eu/en/publications/efsajournal.htm)
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