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Bee health in Europe - Facts & figures

Compendium of the latest information on bee health in Europe

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OPERA is a young, growing think tank and a research centre of the Università Cattolica del Sacro Cuore, a major European private university.

It is an independent, non-profit scientific organization, committed in supporting the successful implementation of the agri-environmental measures within the European legislation.

The fundamental contribution of OPERA is to use the potential of existing scientific researches as well as the existing expertise and knowledge to support the stakeholders in their political and technical decisions concerning agriculture, and particularly the management of agricultural risks relating to pesticides and the environment. One objective is to provide a series of pragmatic recommendations to policy makers to bridge the interest and objectives of agriculture and environment as well as to ensure efficient implementation of the agriculture related policies in the EU.

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EXECUTIVE SUMMARY

The focus of this document is to gather the latest information available on the factors influencing the health of both managed honeybees and populations of native wild bees, including solitary bees and bumble bees.

The report starts from the premise that declines in pollinating insect numbers can have significant adverse effects ecologically on the diversity of plant species and economically in the productivity of crops. However, up until now, the status and relative importance of the stress factors that may affect bee populations has been relatively unclear and, in many instances, widely disputed.

In Europe there are known to be at least 700 bee species, but only one, *Apis melliflera*, is managed for honey production. According to the European Commission Communication on Honeybee Health (COM (2010)714final), the number of beekeepers in the EU is estimated to be approximately 700,000, keeping around 15 million hives. Around 97% are non-professional beekeepers, who account for approximately 67% of EU hives.

Economics of beekeeping

Whilst there is very limited information on the economic aspects of beekeeping across Europe, keeping bees on a small scale is widely recognized as being uneconomic. However, it is still very widely practiced. Fluctuating prices, market access, counterfeit products, labor and costs with other the inputs needed in beekeeping activities all have a strong influence on the honeybee population. Beekeeping is also influenced by globalization, with honey production becoming more concentrated in Asia, Africa and South America.

Honeybee colony decline

Decline of honey bee colonies have been reported mainly in central Europe, but the situation in not universal, since in Mediterranean countries increases have been observed over the past decades. The media frequently reports alarming numbers of colony losses, but in many cases the reasons for decline - which are typically complex and multifactorial in effect - are poorly investigated and the information given on overwintering colony losses is often misleading. Typically the implication is that decline in honey bee colonies is affecting all bee species, when the causes and effects are more often specifically related to the keeping of hived bees.

Whilst overwintering colony losses have increased by trend in the last decade, these are not significantly different for single years registered in the past. When high colony losses are reported, most reports from Europe are about overwintering losses caused by the *Varroa* spp. mites, often linked with secondary infections by viruses and losses caused by *Nosema* spp.

The outcome of the multifactorial monitoring projects reported so far seems to suggest that the parasitic pest mite *Varroa* spp., which can be found in almost every apiary in Europe, is the main causative factor involved in honeybee colony weakening in Europe.

Other diseases like *Nosema* spp., virus infections, or foulbrood, may also damage colonies during spring and summer. Due to the lack of veterinary treatments, parasites and diseases commonly affect these bee populations Furthermore, it is also expected that diseases which are not currently present in Europe, such as the small hive beetle or the *Trolilaelaps* spp. mite may appear and spread. The efficacy of current treatment options, where they are used, varies based on beekeeping practices, climatic conditions and different seasonality.

Colony Collapse Disorder (CCD) as described in USA has not been observed in Europe.

Controlling bee pests and diseases is seen as the essential factor for successful beekeeping over the years. Some countries made important efforts to implement specialized training programs for the recognition of diseases; in others this skill is gravely underdeveloped with beekeepers.

Additionally, as beekeeping techniques, cultural traditions and climatic conditions vary around Europe, greater attention should be paid from the policy side to the development and implementation of good beekeeping guidelines. New beekeeping techniques and improved knowledge have resulted in improved bee health and higher quality and quantity of honey yields.

Native pollinator populations

Studies, in particular multifactorial studies undertaken on the honey bee, indicate that losses of pollinators are likely to be caused by a combination of several pressures, including habitat loss, climate change, diseases, beekeeping practices, invasive species and pesticides. Habitat destruction has been determined to be one of the major causes of pollinators' decline.

Many modern crops do provide essential food resources for both wild and domestic bees, in particular nectar and pollen. Farming practices such as crop rotation, sowing bee attractive flowering crops, maintaining orchards and hedges and planting flower rich meadows, along with actively managed field margins and buffer strips, can contribute to increasing populations of native wild bees and other pollinating insects.

The focus of the majority of bee disease research has historically concentrated on *Apis* honeybee species. As a result, a considerable knowledge gap exists concerning the incidence, effects, causes of and remedies for diseases in wild bees. It is clear that to maintain health, foraging bees need a variety of sources of natural nectar and pollen to prevent nutritional deficiency and to strengthen immune defenses.

Pesticide links

Pesticides are listed by many authors as a potentially contributing factor to honeybee colony losses, but there are only few investigations that claim to have found concrete evidence for a key role of pesticides. Reported pesticide incidents typically lead to a varying degree of damage on the colony, but rarely the loss of damaged colonies. The most frequent cause of pesticide-related incidents is the misuse of products and ignorance of label statements by farmers, combined with a poor communication with beekeepers, or disregard by beekeepers for good practices. Single events of poisoning with pesticides have thus been reported in many countries.

The role of multiple pesticide residues in sub lethal amounts, or the impact of combinatory and synergistic effects on bee health, evaluated also in the multifactorial studies, requires further investigation. However, such research does not preclude the need to strictly respect and adhere to the approved conditions of use for pesticides, which are designed to avoid exposure.

In discussing the pesticide exposure of bees, it is essential to consider if bees will be physically exposed to a product in the course of its use, based on the details of the product and its pattern of use. In some cases exposure of bees is not possible, and in case it is, a second consideration is the attractiveness of the crop plant. These are elements considered in current risk assessment schemes and as a consequence, the evaluation of incident reports, established in eight European countries, show that the number of pesticide-related bee incidents has generally declined for the past decades in the monitored countries.

Several post-registration monitoring studies have also been performed in countries across Europe to assess the impact of certain pesticides on bees in their predefined use conditions. Most of these were focused on neonicotinoid substances. None of the pesticide-related bee monitoring in real-life conditions of use have, so far, found a clear connection between bee colony mortality as a general phenomenon and the exposure of bees to the pesticides. These have proved that the mitigation or stewardship measures decided at the approval of the respective products have been effective if complied with.

Multi factorial studies are the most dedicated approach as they are designed to quantify the relative contribution of each of the parameters monitored to any losses. Researchers agree that even if infestation with *Varroa* spp. is one of the major factors, a multi-factorial origin of the observed colony losses is most likely to be the cause. Other factors include a multitude of diseases and parasites, hive management and beekeeping practices, climatic factors, queen health issues, nutritional problems, loss of genetic diversity, and environmental factors such as the structure of modern agricultural landscapes.

EU pesticide legislation

The EU legislation on pesticides relies on two complementary texts (Regulation 1107/2009 and Directive 128/2009) that aim to ensure a high level of protection of humans and the environment. From the regulatory perspective, the knowledge on the possible impact that pesticides may exert on the honeybee is far more detailed and documented than for other pollinating species or species of terrestrial and aquatic ecosystems.

The evaluation of the impact of pesticides on bees has been undertaken for many years in Europe, using guidelines developed by OECD and EPPO which provide for methods to assess the impact on honeybees and on other non-target species.

The EU Regulation on pesticides (Regulation 1107/2009) includes a specific requirement for risk assessment on the honeybee (*Apis mellifera*) where they may be exposed. This provision was also covered by the approval procedure under the previous framework, Directive 91/414.

EC Regulation 1107/2009, and previously Directive 91/414, requires demonstration that the placing of individual products on the market and their recommendations for use complies with the protection goals, including those for bees. The registration of pesticides relies on a strict set of rules for the constitution of dossiers and risk assessment which allow, for each use, to define conditions of use to ensure their safety. Risk management measures may be recommended, which are product-specific and appear on the labelling.

Directive 2009/128 (the Sustainable Use Directive) extends the set of measures, from the training and certification of users to the control of application machines and the development of effective mitigation measures that would improve the safety level over the whole process of using pesticides.

Many recommendations for proper pesticide use and good stewardship practices have been developed to help mitigate the potential for harm to pollinators. These publicly available guidance documents offer steps to protect pollinators and their food sources, water and habitat.

Post registration studies and multifactorial studies, both investigating pesticides as a potential source of impact in honey bee colonies, confirm the key role of field and landscape management in maintaining colonies in a high health status. Thus one further is the use of multifunctional landscaping and active management of the areas adjacent to the cropped fields, to provide additional food and habitat resources for pollinators. Such practices should eventually be seen as the basis for crop management in future.

From this analysis, several aspects for action can be highlighted

- Beekeeping is a highly complex activity; steps need to be taken to train beekeepers, especially amateur ones, to become more professional.
- Efficient treatments for honeybee colony pests need to be urgently made available. Monitoring of resistance to different treatments is equally important.
- Guidelines for beekeeping practices and especially for hygiene procedures need to be developed for all, especially hobby beekeepers.
- Monitoring tools are best placed to collect data on colony losses, and to identify factors that contribute, hence such monitoring actions should be promoted throughout the EU, learning from the systems in place.
- Where risk management options are required for the safe use of certain pesticides, these should be better communicated among and within EU Member States so that knowledge and technical improvements may be shared and implemented quickly.
- Habitat conservation considering the needs of pollinator species is a key aspect in reversing the decline where they occur.
- To contribute to meeting nutritional needs of healthy bees, including migratory beekeeping, the policy needs to encourage farmers to actively manage and develop bee habitat.
- Continuation and strengthening of research activities, including those on bee pests, diseases and on pesticides are particularly important.
- The economic support for beekeepers is essential so as to compensate their high costs in combatting bee pests.

COORDINATOR

Anne Alix participated to EU working groups on honey bees, in ICPBR, EPPO, OECD and the EFSA. She leads ICPBR working groups on systemic products and monitoring; and co-chairs the OECD working group on pollinators. After a PhD in Ecotoxicology, she worked as an environmental risk assessor. She joined in 2001 the office in charge of the scientific evaluation of pesticides for the French Ministry of Agriculture (INRA) and in 2006 as the head of the unit in charge of Environment and Ecotoxicology for the French Agency on the safety of Food (AFSSA). Since April 2010 she works on risk management and post registration monitoring for pesticides in the French Ministry of Agriculture.

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CHAPTER 1. THE SITUATION IN THE EU

1.1. Context

In addition to many agricultural crops, numerous different wild plants depend on insect pollinators. Pollination is of high economic value and an essential ecosystem service. Vegetable and seed production from a large number of the leading global food crops is dependent upon animal pollination, while many other crops do not rely upon animal pollination (Klein et al., 2007).

For honey bees, by far the most important contribution they make to agriculture is the pollination service they provide (van Engelsdorp et al., 2009). The direct value of honey produced in the EU is estimated about 140 million € (Moritz et al., 2010), while the value of insect pollination for European agriculture has been estimated to be around 20 billion € per year and approximately 153 billion € worldwide (Gallai et al., 2009).

More than 1000 bee species are known in Europe (Müller et al., 1997). These vary greatly in size, foraging behaviour and specialisation on certain plants, life cycles and habitats. As not all different wild bee species have been constantly monitored over time to assess population developments, it is not easy to make a general conclusion on population trends.

Scope:
While there are many insect species involved in pollination, for the purpose of this document we will focus on the managed honeybees and wild bees (solitary bees, bumble bees).

Pollinator declines can result in loss of pollination services which would have important negative ecological and economic impacts and could significantly affect the maintenance of wild plant diversity, wider ecosystem stability with potential knock on effects on crop production, food security and human welfare.

Declines of managed honey bee colonies and also of some wild bee species have been reported by many countries, but the situation is not homogenous; in some countries increases have been reported depending on the species. There is clear evidence of recent declines in both wild and domesticated pollinators, correlated with parallel declines in the plants that rely upon them (Potts et al., 2010; Moritz et al, 2007; De la Rua et al., 2010).

With regards to honey bees, the media often reports impressive numbers of colony losses and these are used to describe the decline of bee colonies. In many cases the reasons for decline are poorly investigated and the information given on overwintering colony losses is often misleading; looking solely at numbers of yearly overwintering losses it would be easy to conclude that the honey bee is close to extinction, which is clearly not the case.

By re-queening colonies and creating more nuclei bee hives, beekeepers are able to compensate for losses, thus beekeepers need to maintain increasingly large bee populations to assure production capacity.

Examination of the historical record shows that extensive losses are not unusual (e.g. Fleming, 1871; Beuhne, 1910; Rosenkranz, 2005; Afssa, 2009; van Engelsdorp and Meixner, 2009). Abnormally low honey harvests were likewise reported in the past, before modern agriculture developed, by significant percentages of beekeepers, such as 23% of them in 1894 and 69% of them in 1926 (Afssa, 2009). In the UK, losses before 1940 were mainly caused European Foulbrood, American Foulbrood, starvation and poor weather.

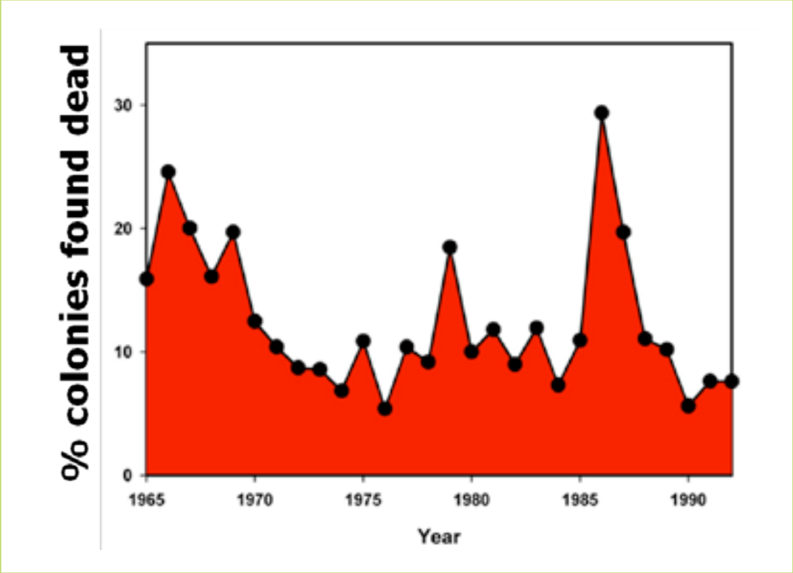


Figure 1

Percentage of colonies identified as dead in the UK during colony inspections (includes both over-wintering and within year losses)

In contrast to managed honey bee colonies, data on development of populations of wild bee species are rarely reported; the available data relies solely on research activities, usually limited to a few species, and on field observations related to crop yield losses (Aubertot et al., 2005).

For wild species with demonstrated declines, it is often difficult to determine the causes and the consequences of their decline. However, for all pollinators, especially wild bees, the composition of landscapes and the availability of suitable habitats are key factors influencing the survival and the development of bee populations (Potts et al., 2010). Cropping regimes may also have a significant impact on pollinators. In addition to wild floral resources, some wild bee species forage on agricultural crops and may be aversively affected by pesticides.

1.2. Figures and Trends in Bee Populations in Some EU Countries.

As far as honey bees are concerned, according to the European Commission Communication on Honey bee Health (COM (2010)714final), the number of beekeepers in the EU is estimated to be approximately 700,000, keeping around 15 million hives. Around 97% are non-professional who account for approximately 67% of EU hives. Honey production is estimated to be close to 200.000 tons/year.

The number of managed bee colonies depends on different factors. Surveys of managed colony numbers indicate declines in colony numbers for central Europe but some increases in Mediterranean countries. However, patterns are very heterogeneous (Potts et al., 2010). Statistics need to be interpreted carefully as different approaches are used in different countries, for data collection, but definitely the number of managed honey bee colonies is in first place closely linked with the numbers of beekeepers.

Honey bee loss is not a new phenomenon and has been associated with disease, starvation and poor weather. For wild species, due to lack of monitoring data, it is difficult to establish a trend.

In the United States higher numbers of colonies losses due to CCD (Colony Collapse Disorder) have also been reported.

In Europe overwintering losses have tended to increase in the last decade, although current overwinter losses do not necessarily differ from those reported in single years in the past (see e.g. for Germany, Rosenkranz 2005, and Schroeder, 2011). When high overwinter colony losses are reported, most accounts from Europe are about overwintering losses caused by the *Varroa destructor* mite as the main cause, often linked with secondary infections by viruses and losses caused by the microsporidian fungus *Nosema*.

***Colony collapse disorder (CCD)**, is a disorder affecting honey bee colonies that is characterized by sudden colony collapse, with significant amount of brood and stores but a lack of healthy adult bees inside the hive. (Ellis et al.l, 2010, van Engelsdorp et al., 2009).*

***CCD as described in USA has not been observed in Europe** (Genersch et al., 2010; EFSA, 2009).*

The exact number of managed colonies is hard to determine, as methods for data collection vary between countries (Potts et al., 2010). Also it is likely that numbers reported do not represent all bee colonies as some beekeepers are not organised in confederations; also those organised in confederations do not always state the correct numbers e.g. as insurance is calculated per hive.

With regards to wild bees, Biesmeijer et al. (2006) demonstrated that in both U.K. and Netherlands wild bee diversity has fallen significantly in most landscapes, and that mobile generalist bee species tend to increase, whereas diet and or habitat specialists and sedentary species tended to decline. Parallel, losses of species diversity in wild plant communities were observed.

1.3. Assessment activity and methods for bee population trends

1.3.1. Colony losses

Definitions of colony losses and incidents and on their reporting format vary from one country to another, which is the first difficulty met in attempts to get an overview of the global situation (EFSA, 2009). A proposed set of definitions that distinguish between different types of colony "losses" observed in honey bee populations has been published by Afssa (2009) (Table 1). Definitions have yet to be appropriately adapted to encompass wild bees, losses in wild bees being described in terms of typical ecological indicators like abundance or diversity indices.

Table 1

Die-off, weakening, depopulation and collapse of bee colonies, from Afssa, 2009.

Qualifier	Decrease in the number of bees		Decrease in colony activity		Decrease in honey production	
	Rapid	Gradual	Yes	No	Yes	No
Die-off	✓	✓	✓		✓	✓
Weakening	(✓)	✓	✓		✓	
Depopulation		✓	✓		✓	
Collapse	✓		✓		✓	✓[1]

[1] Bees do not produce large quantities of honey all year long. Periods known as "honey flow" (i.e. transport of nectar and making of honey), during which large quantities of nectar are accumulated exist. If the collapse occurs after the honey flow, there will be no noticeable reduction in honey production.

With respect to the honey bee, the European Food Safety Authority (EFSA) has collected feedback of survey programs and honey production in European MS (EFSA, 2008). This report is by far the most comprehensive review undertaken on the honey bee and statistics were provided for almost all countries for 2006 and 2008. More data are available in some countries where a survey is regularly performed as in the UK *(www.NationalBeeUnit.com)*, in Germany *(www.deutscherimkerbund.de)* and in France (Institut Technique et Scientifique de l'Apiculture et de la Pollinisation, *www.cnda.asso.fr*).

1.3.2. Disease related incident recording

Disease recording incident systems are present in many countries around Europe. However, their reporting is not always systematic and it is focused on the diseases specific to a certain region.

For example, in on behalf of the national governments for England and Wales, the National Bee Unit (NBU) has been responsible for the inspection of colonies for pests and diseases, the control of statutory bee pests and diseases and training for beekeepers for over 60 years. The NBU's integrated programme includes laboratory diagnostics, programme support, research personnel and bee inspectors. The training for beekeepers covers many aspects of beekeeping, pest and disease recognition and control and good husbandry and includes over 700 training events for beekeepers each year. This is probably the most complete disease surveillance scheme in the EU and includes a database of resources for beekeepers (*www.nationalbeeunit.com*) including maps of disease incidence.

1.3.3. Pesticide incident recording

In several European countries, there are recording and investigating systems existing for pesticide-related poisoning incidents with bees. In the UK, for instance, honey bee poisoning incidents are reported by the Wildlife Incident Investigation System. The system relies on a voluntary declaration of mortality and losses by beekeepers. Enquiries are performed based on the description of the case and symptoms.

These reports, being documented according to dedicated protocols, have constituted a valuable source of data with regards to the implication of pesticides, a more precise indicator of effects related to the use of a particular product and of the conditions during the occurrence of an incident. In Germany, a similar system is maintained by the Julius-Kühn-Institut (Thompson and Thorbahn 2009); as well as in Italy where the communication are delivered to the local public veterinary services and recently a national monitoring network has been established (APENET, 2009-2010).

Incident reporting is carefully considered by regulators; lessons learned from accidents have proved to lead to quick reaction and adaptations of regulatory processes. A more broad alert system, which would allow all countries to be rapidly informed about any accident/misuse, is under development by the OECD.

For example, incidents reported in Germany in 2008 following the sowing of seeds defectively coated with insecticides (Pistorius et al., 2009) have acted as an "alert" to the possible risks that may arise from an exposure to the seed dusts created at sowing, under certain circumstances (Foster, 2010, Nikolakis et al., 2009). As a result, risk management measures have been implemented almost immediately in many countries (JORF, 2009, BVL, ZALF, 2009). This incident, together with previous observations on the emission of dusts at sowing under particular circumstances, has led to the inclusion of this route of exposure on the list of the relevant routes to be considered when defining the conditions of exposure for ecosystems and pollinating species (EC, 2009-annexes). Additionally a workshop has been held in Paris in May 2011 and recommendations with regard to conditions of sowing and further risk assessment are being elaborated (Alix pers. com).

Similar approaches are on-going in other countries, e.g. in Canada with CANPOLIN (Canadian Pollinator Initiative) and across North America with NAPPC (North American Pollinator Protection Campaign).

1.3.4. Current Research projects

In addition to the statistics provided by incident reporting schemes, valuable data may be provided by research activities (see box). The aim is to work at identifying the possible causes of the declines or losses reported and develop/support research projects to further explore the hypothesis emitted. Key knowledge gaps in the research on pollinators have been identified and addressed by the scientific community in different projects.

A very recent development is the designation by the European Commission of a European Union Reference Laboratory for the issues related to bees. The main task is to implement a pilot monitoring project over the EU to assess the situation and then to propose a framework for the implementation of a harmonized monitoring system.

Research projects in the EU

Focus on honey bee pathology and interactions between pathogens:

- *International Research Networks COLOSS (prevention of colony losses),*
- *Bee DOC (Bees in Europe and the Decline of honey bee colonies,),*

Focus on pollinator loss across insects:

- *STEP EU (Status and Trends of European Pollinators*

Focus on developing and testing methods for assessing large-scale environmental risks:

- *ALARM (Assessing Large-scale Environmental Risks for Biodiversity with Tested Methods)*

The Coloss Network (Prevention of Honey Bee COlonyLOSSes (2008-2012), an international European-funded COST (European Cooperation in the field of Scientific and Technical Research) network, is one of the most important network on the issue (see Annex I for an example of activity).

Their work is organized around 4 working groups focused on: i) monitoring and diagnosis; ii) pests and pathogens; iii) environment and beekeeping; and iv) diversity and vitality. As a part of the work, the "Bee Book" is to be published, defining international standards for large-scale monitoring and research activities.

As a very high number of interacting variables and inter-regional differences exist, the broad approach of such a large network significantly improves detection, further understanding, and mitigation of the drivers of colony losses and losses of wild bees.

Long-term research efforts have been focused on developing ways to manage landscapes to safeguard pollinators and allow them to continue to provide pollination services, which benefit everyone. To meet these goals, there are several large-scale global research programs specific to pollinator research and many more on biodiversity and climate change impacts.

Taken together, these research programs will improve the understanding of the nature, causes, consequences and potential mitigation of declines in pollinators at local, continental and global scales:

- Project *Status and Trends of European Pollinators* (STEP)*(www.step-project.net)*
- Project *Apis m.* (PAm) *(http://www.ProjectApism.org/)*
- Managed Pollinator CAP (Coordinated Agricultural Project) *http://www.beeccdcap.uga.edu/index.html*
- US EPA Pollinator Protection: Advancing the Science *http://www.epa.gov/opp00001/ecosystem/pollinator/science.html*
- NSERC-CANPOLIN Canadian Pollination Initiative: *http://www.uoguelph.ca/canpolin/index.html*
- Project CLIMIT- CLimate change impacts on Insects and their MITigation: *http://www.climit-project.net/index.php*
- UNEP/GEF/FAO Global Pollination Project: *http://www.sanbi.org*
- Honey bee Forage Project: *http://www.sanbi.org*
- APENET a public national project dealing with the monitoring of the accident, monitoring the well being of the bee colonies, development of the mitigation measures and the analysis of the biotic and abiotic risk factors: *http://www.reterurale.it/apenet*

Early results indicate that losses of pollinators are likely to be caused by a combination of several pressures including habitat loss, climate change, diseases, invasive species and pesticides.

Further important knowledge is provided by the multi factorial studies described in Chapter 4.2.5.

It is noteworthy that most of the incident reporting data and research projects still focus on the honey bee and little data deal with wild species. A better balance in the efforts involved towards wild species is deemed necessary for the reason that their role in biodiversity and pollination is as important as for domesticated species, and also because of the difficulty to monitor these species as for domesticated species.

CHAPTER 2. BEEKEEPING AND ITS INTERACTION WITH AGRICULTURE

2.1. The role of the bees in crops

Bees are mainly attracted to crops by the presence of nectar and pollen, which are valuable food sources. As a consequence of this interaction, bees provide a valuable pollination service for some but not all crops. For example, production of 39 of the leading 57 crops world-wide increases with visits by pollinating animals, which in aggregate accounts for 35% of global food production (Klein et al., 2007).

In a study investigating the causes of 23 reported cases of reduced crop yields caused by reduction in pollinator numbers, the majority of the reduced pollination services were attributed to crop management practices (Aubertot et al., 2005).

In contrast, animal pollination is irrelevant to the remaining 18 of the 57 leading crops which comprise 60% of world production (Klein et al., 2007). Such crops (e.g., cereals, maize and sugar cane) are generally wind or passively self-pollinated. Similarly, crops such as potato, sugar beet, spinach and onions also do not require insect pollination except for seed production.

Solitary bees live alone or in small colonies without complex social interactions. Some wild bees have highly selective habitat requirements which limit their exploratory range and therefore their potential for pollinating many different species of plant. Bumble bees are social insects; they live in small annual-cycle colonies and are sometimes supplied and used as pollinators for crops grown in greenhouses.

Apis mellifera is the only managed honey bee species in Europe, which has been domesticated by beekeepers to produce both honey and provide pollination services. Selective breeding has resulted in a number of strains specific to certain regions that may have different susceptibility to pests and diseases. When wild bees do not visit agricultural fields, managed honey bee hives are often the only solution for farmers to ensure crop pollination. Indeed, *A. mellifera* remains the most economically valuable pollinator of crop monocultures worldwide (Klein et al., 2007).

2.2. The Crop as a Habitat for Bees

The modern day prevalence and distribution of bees in the agricultural landscape has been very much shaped by human behaviour. Many modern crops provide essential resources for both wild and domestic bees, in particular nectar and pollen. Oilseed rape, which is widely grown in many areas of Europe, is one such example, as are sunflowers and orchards, especially as a traditional springtime source of feed for bees (ELO/ECPA/RifCon/E-Sycon, 2011).

Conversely, fragmentation and degradation of near- and semi natural habitats in the agricultural landscape can be detrimental to bee communities, with the main causal factor being loss or dissociation of food, for both managed honey bees and wild bees, and nesting resources for wild bees (Klein et al., 2007; Potts et al., 2010).

Although some agricultural management practices resulting in habitat destruction, fragmentation or degradation have been identified as causes for pollinator's decline, especially for wild bees, other farming practices can contribute to population increase.
Such practices include: crop rotation, sowing bee attractive crops, flower rich meadows, orchards, hedges, flowering crops, actively managed field margins and buffer strips.

In a review investigating the causes of declining pollinator numbers in agricultural habitats, a number of factors were investigated including intensification, pesticide use, agricultural land use and road construction. Of these potential causes, habitat destruction (e.g., through removal of hedges, development of monoculture practices, irrigation practices, etc.) was determined to be the major cause of such reported declines in pollinator numbers (Aubertot et al., 2005).

An analysis of national scale plant species datasets from the UK has shown that bumble bee forage plants have experienced significantly greater declines than other native species during the 20th Century, including those of particular value for threatened bumble bee species (Carvell et al, 2007).

In Europe, policies, regulations and market conditions play a significant role in determining agricultural activities. However, farmers still have the freedom to manage their land in ways that can have a range of implications for bees. Some land management practices do not favour bees. For example, in many areas of Europe, flower-rich meadows have been replaced by crops or meadows which provide little or no resources for bees during the summer months.

In contrast, some agricultural land use practises can favour bees. For example, flower rich meadows, orchards, hedges, flowering crops, field margins and buffer strips can all provide valuable food sources and habitats for bees. An example of an agricultural land-use practice, which is specifically aimed at benefitting pollinators, is the pro-actively sown pollinator strip, which has been shown to be very attractive to wild bee species and other pollinator species (Carvell et al, 2007).

During European springtime, agricultural landscapes with crops and wild plants can provide a surplus of nectar and pollen. However, passage through the seasons sees a reduction in the availability of forage to levels which may be insufficient to maintain robust bee populations.

Cropping regimes can also have significant impact on bees. Rotating land use from one agricultural crop to another over time provides important seasonal diversity of pollen sources, and can reduce requirements for fertiliser. Similarly, the practise of fallow crops (*e.g.*, clover and *Phacelia weed*) to allow soil recovery and support soil organism development, can result in a greater diversity and occurrence of flowering plants of significant value to bees (ELO/ECPA/RifCon/E-Sycon, 2011).

Clearly, conservation of near and semi-natural land that surrounds and divides cultivated fields has tremendous potential value for bees and the resulting pollination service (Klein et al., 2007). For example, bees can benefit from increased habitat and food provision where buffer zones (uncultivated margins), drainage ditches and natural water bodies are established. Buffer zones and field margins also serve to improve the connectivity of green infrastructure, which is of value to biodiversity in general.

2.3. Modernisation of Beekeeping

Domestication of honey bees began thousands of years ago. Honey harvest usually led to severe damage to colonies until in the 18th century when the first hive systems for beekeeping and moveable frames were established. Improvement of hive systems, according to the developing knowledge on bee's needs, has enormously facilitated beekeeping practices and the maintenance of good bee health as well as improvements in migratory beekeeping.

Targeted breeding has allowed the development of colonies with lower susceptibility to some diseases (like chalkbrood), improved honey yield, reduced swarming and reduced aggressiveness.

New beekeeping techniques and improved knowledge have resulted in higher quality and quantity of honey yields, improved bee health and some reduction of the work needed to maintain the hive.

Nevertheless, unlike other companion animals, automation of the beekeeper's work with the colonies, for the most part, is not possible. Automation is limited to honey extraction, filling, and labeling. Some technological advancement has been developed for moving colonies, but usually these are affordable only for professional migratory beekeeping. Modernisation of hive systems, technical support and market demands (despite the lack of sufficient forage during the year in some regions) have led to an increase in migratory beekeeping.

2.4. Good Beekeeping Practices

Keeping honey bee colonies requires some basic knowledge; successful beekeeping considerably more. Beekeepers need to understand the biology and behavior of bees and the changing needs of bee colonies throughout the year. This understanding is essential to enable vital growth conditions, to keep bees healthy during the whole year, and to maintain strong, healthy colonies with sufficient food resources for successful overwintering.

Modern beekeeping is highly complex activity, requiring extensive knowledge of biology and behavior of bees, medical treatments for their diseases, techniques to re-queen colonies, understanding the location, climatic conditions, forage needs and hygiene.

European beekeepers need a stable and reliable system for acquiring such knowledge as well as a uniform framework for the recognition of their profession.

In spring, only healthy colonies with certain strength and a minimum number of bees will develop into colonies that may achieve a good honey yield later in the season. Some diseases, poisoning incidents, bad beekeeping practices, and mistakes with treatments may damage adult bees and bee brood, resulting in colony weakening. Weakened colonies produce less honey and are more susceptible to diseases and health problems.

Controlling bee **diseases** is the most essential factor for successful beekeeping over the years. In most regions of Europe, colonies that are incorrectly treated against the *V. destructor* mite, for example, will be likely not to survive the winter.

There are a variety of *Varroa* management methods available, but **treatments** need to be used carefully to avoid damaging the bees and to prevent residues in honey and hive. Furthermore, the efficacy of a treatment varies based on beekeeping practices, climatic conditions and different seasonality. Thus it is of crucial importance, that beekeepers are not only well informed about the identification and biology of diseases; they also need to be aware of the strengths and limitations of different treatment methods.

In areas where honey is produced later in the season, and where higher numbers of colonies from **migratory beekeepers** are concentrated, special attention has to be paid to bee health, as diseases may spread particularly easily.

Migratory beekeeping requires special additional knowledge. As migrating results in stress for colonies the transport needs to be well prepared to avoid damage. Mistakes during transport may prove to be lethal to the colonies.

A frequent **rejuvenation** of colonies is important to keep healthy and vital colonies. The beekeeper needs to be well informed on procedures to create nuclei and rejuvenate queens, e.g. by queen breeding and consequently ways to enable vital growth conditions.

Location for colonies should be chosen by carefully considering the microclimate, as an unfavorable location may result in a lower honey yield and adverse effects on bee health. In some circumstances it may be useful or necessary to supply a water source for the bees.

During the whole year, but especially during overwintering, the beekeeper needs to ensure that colonies possess enough **food resources** and if necessary needs to feed them supplementary (sugar syrup, protein patties, etc.) to maintain vitality and avoid starvation.

Hygiene in the hive needs special attention in the beekeeping practice. To maintaining bee health, old combs should be frequently removed and replaced with new combs with fresh wax.

Also, part of a good beekeeping practice is knowledge of **honey production,** storage, food safety issues and hygienic requirements. To meet increasing hygiene criteria and market needs, significant investments are required, but often are not affordable for hobby beekeepers. As a large number fall under this category, increasing requirements can force the abandonment of smaller apiaries.

As a minimum an occupational standard for the recognition of the beekeeper profession would need to touch upon the following subjects:

- ✓ *General organization of the work and professional training*
- ✓ *Worker protection and sanitary-veterinary standards*
- ✓ *Supply of raw materials and information on genetic stock selection*
- ✓ *Income and expenditure plan*
- ✓ *Specific documents for a bee farm*
- ✓ *Preparing the bee colonies for hibernation*
- ✓ *Organisation of the spring work in the bee farm*
- ✓ *Organisation of the migratory beekeeping*
- ✓ *Reproduction of the bee colonies*
- ✓ *Ensuring bees' health*
- ✓ *Harvesting and conditioning of the bee products*
- ✓ *Marketing of the bee products*
- ✓ *Improving honey production*

There is a lot of literature on beekeeping practices developed in Europe and worldwide. Just as examples we can mention the manual used in Czech republic, prepared thanks to European funding by Titera et al., (2009), or the recent contribution from Brodschneider and Crailsheim (2010) and also in the US (e.g. Heintz et al., 2011). In addition, various books and manuals are available by various authors addressing the issue.

In certain countries (see UK Bee Health Strategy) important efforts have been done to implement specialized training programs for the recognition of diseases.

Recommendations to implement quality training in European Member States (MS) have been put forward by the European Commission and the European Council and these have been identified as a priority (COM(2010)714final; 8606/11 ADD01REV1).

As the approaches, cultural traditions and climate conditions vary around Europe, greater attention should be paid from the policy side to the development and implementation of good beekeeping guidelines.

CHAPTER 3. ECONOMIC CAUSES FOR HONEY BEE DECLINE

Today, 65 million bee hives exist in the world and these produce an estimated 1.5 million tons of honey each year (Food and Agriculture Organization (FAO), 2009). World honey production per bee hive is on average around 20 kg and this amount is 33kg in China, 40kg in Argentina, 27kg in Mexico, 64kg in Canada, 55kg in Australia, 40kg in Hungary and approximately 16 kg in Turkey. According to the FAO data, the largest honey producers of the world, for the period 2002-2007 were, in descending order: China, Argentina, Turkey, the USA and Ukraine. The largest world honey exporters in the same period were Argentina, China, Mexico, Germany and Hungary, and largest importers were the USA, Germany, Japan, the United Kingdom and France.

The number of beekeepers and their economic situation, connected with the prices of their products and the costs incurred, has a strong influence on the total number of honeybee colonies.

There are an estimated 15 million hives in Europe, the greatest number is to be found in Spain (2.46 million), followed by Greece (1.5 million). France, Italy, Poland and Romania each have more than a million hives. Since 1965 the number of bee colonies maintained by beekeepers in Central and Western Europe has been declining. However, in Southern Europe (especially Greece, Italy and Portugal) the number of colonies showed an increase between 1965 and 2005. The overall trend for Europe has been a decline in the number of beekeepers (ECPA, 2011 Pollinators and Agriculture).

While managed colonies decreased in some parts of the world (Europe, North America and Japan), increases occurred in Asia, Africa, South America and Australia (see Figure 2). A reduction or increase in the number of colonies in some areas is often simply linked to the number of beekeepers, yet there are many factors that can seriously impact honeybees.

Reasons for beekeeping are very different. Keeping bees on a small scale is often not cost effective. The price of materials and disease treatments are high, so the costs of beekeeping often exceed the income generated. For hobby beekeepers, the majority by numbers, the economic incentive and profit is not usually the primary interest. By contrast, profit is essential for professional and semi-professional beekeepers. Studies worldwide report that the relative profitability of beekeeping operations is likely to be a major influence on the number of managed colonies.

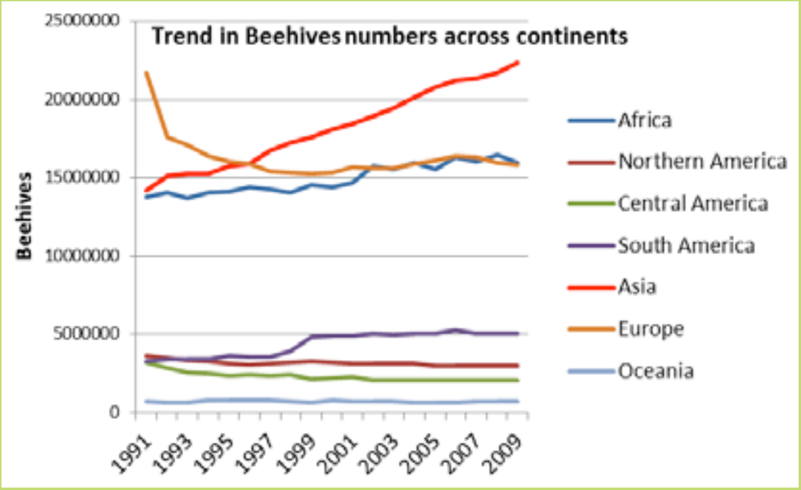


Figure 2

Trend in beehives numbers across continents. Data source: FAOSTAT

While Europe has around 20% of the estimated global number of honey bee hives, little or no information can be found on the economic aspects and challenges of beekeeping in Europe. While some national evaluations might be available (See study cases in Annex II for France, Poland and Romania), there is no comprehensive EU wide study publicly available to evaluate the economic situation of the beekeeping sector.

Colony declines in the US prior to the introduction of the *Varroa* mite have been linked to stagnant honey production figures, while increased colony productivity over the same period has been used to explain increasing numbers of managed colonies in Canada.

In the US pollination services are a source of income for many professional beekeepers, e.g. in almond pollination, whereas in the EU it is rare that beekeepers are paid for pollination services, income mainly relies on selling hive products like honey.

Analysing the relevant data between 1991 and 2009 available for the EU countries in the FAOSTAT database for honey, the most important direct product of beekeeping, we can extract some insights on the economic situation of beekeeping and the challenges with which it is confronted.

In broad terms the price evolution has been rather similar for all European countries. During the period 1991-2009, the price of honey in countries presently belonging to the EU has fluctuated in a very similar pattern. A slight increase in the honey price can be observed up to 1997 – 1998, followed by a sharp decrease up to 2001, in many cases even below the level of 1991 (Austria, Cyprus, Germany, Hungary, Italy, Portugal, Romania, Slovakia and Slovenia). After 2001, the price of honey in Europe rose again or remained relatively stable up to 2007 when we can see again a general tendency to decrease occurred in all the countries.

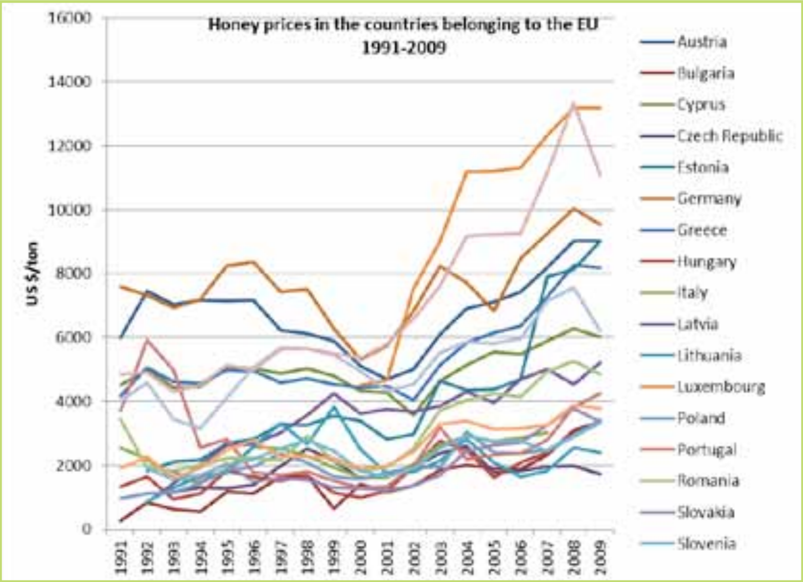


Figure 3

Honey prices in the countries belonging to the EU. Data Source: FAOSTAT

If broken down geographically, this general evolution of honey prices during the above described period can be even more illustrative.

Based on the data communicated and available in FAOSTAT, for countries in Southern and Eastern Europe, the price varies generally in the range of 1500-3000 $/ton with the exception of Greece where the price is higher. For Northern European countries the average price is in the range of 3000-6000$/ton, with the exception of UK where the price since 2004 is above 8000$/ton. For the Western European countries, the price has fluctuated generally between 6000 and 8000$/ton in the reference period.

The accession to the EU of the 10 New MS in 2004, and the additional two in 2007, has not made any significant impact on these gaps in prices. Such a situation can only be explained by the fact that honey markets are usually locally oriented and that the major importers of honey, like Germany or France have not shifted their supply sources after the accession of these new countries to the EU. The major global producer of honey, China, has reported to FAO producer prices varying between 600 and 800$/ton up to 2007 and 1700-1800$/ton in 2008 and 2009.

There are important challenges for beekeepers to market their main product on the European market. First, not all beekeepers can take advantage of the same market opportunities in terms of prices. Second, their comparative advantage to imports lies in the superior quality of the honey they produce, but this is relevant only if the origin of the honey can be proven and the producer recognized by the consumer, hence the local orientation of the markets. The quality aspect of honey is less important when the honey is used for processing purposes.

From 1991-2007, according to the data available and reported to FAO, countries constituting today the EU, have maintained a relatively constant negative balance for honey, between 100.000 tons and 140.000 tons/year. In the same period, the total quantity of honey supplied for consumption in the respective markets has been fluctuating between 273.000 tons and 337.000 tons, meaning that roughly 1/3 of the honey consumption is not covered by production.

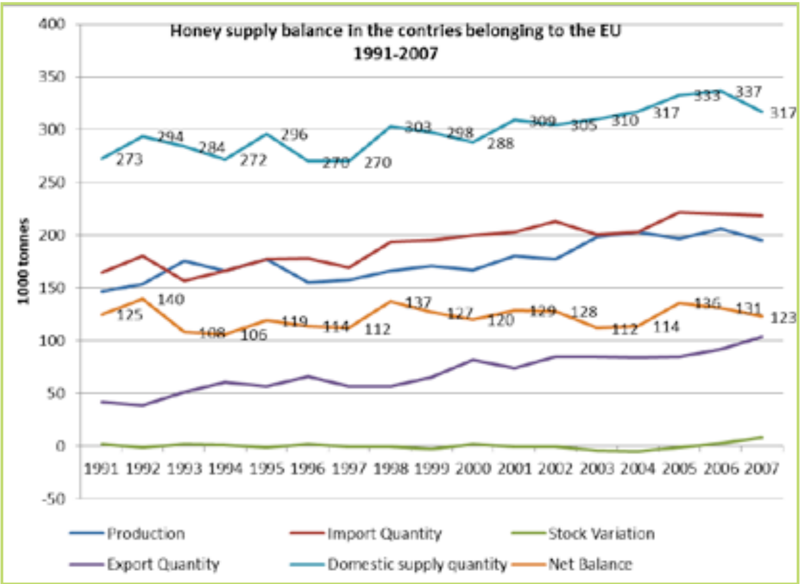


Figure 4

Honey supply balance in the countries belonging to the EU. Data Source: FAOSTAT

A significant factor in our analysis is the evolution of the beehives in these countries correlated with the above economic parameters. The sharp decrease in the total number of beehives between 1993 and 1997 is generated by the structural changes and economic difficulties of the Eastern European countries which have experienced relevant drops in their stocks (around 12%). These were partially compensated by the increase in numbers in other European states (especially southern states) due to better honey prices.

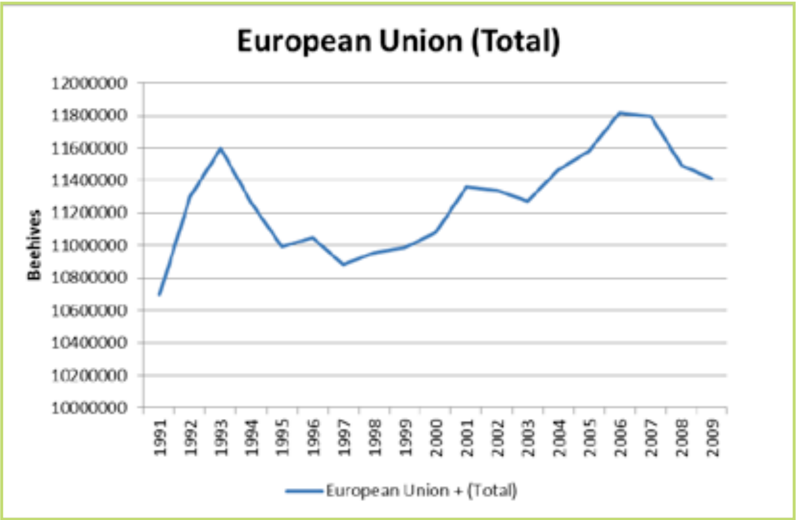


Figure 5

Number of beehives in countries belonging to the EU. Data Source: FAOSTAT

2001 is the turning point where better honey prices for European producers and the support program financed by the European Commission began to strongly influence the stocks. Prior to 2007 there was a strong increase in the total number of beehives. Since 2007, the lower price of honey has a negative influence on the profitability of beekeeping, generating a strong decrease in the number of beehives almost to the level of 2001.

The data suggest that there is a strong correlation between the number of beehives and the prices of honey and other apicultural products. Additionally, the financial support granted by the EU to the beekeeping sector, which has partially compensated the costs incurred by beekeepers to fight the bee pests has produced a positive results in increasing the stocks.

As pointed out by professional association COPA COGECA, the marketing problems beekeeping is facing in Europe are related to the lack of information on the market, mainly statistics and forecasts, and to the difficulties in placing the products on the market. The last one is exacerbated by the heterogeneous marketing standards for certain hive products; unfair practices of adulteration of honey; residues in hive products.

European Commission notes in its 2004 report on the implementation of the support programs for beekeepers that: "There is a substantial difference between the prices of imported honeys and producer prices for high-quality European honey, which may increase further with the opening up of the markets (China's entry into the WTO, preferential agreements, etc.). Under these circumstances, beekeeping is no longer an attractive activity, even though Community production covers under less than 50% of EU demand. Even part-time beekeepers are no longer motivated."

Lately beekeepers have reported an increase in incidences of fraud with bee products, ranging from adulteration of honey to recycling damaged honey, abusive labelling practices, missing information on labels and development of imitation products.

Additional difficulties reported by the European professional organization are price volatility and very low profitability of the beekeeping activity.

From the structural point of view, the prospects are not encouraging, bearing in mind that age structure of beekeepers is not appropriate, with a large percentage older than 50 years, and generally the number of beekeepers is continuously falling. However, reports from Germany and UK indicate a positive turn in this trend.

Beekeepers have identified a clear need to promote the professionalization of beekeeping, since the activity today needs to meet complex requirements in bee wellbeing, hygiene and market parameters.

CHAPTER 4. THREATS TO BEE HEALTH AND HOW TO DEAL WITH THEM

European statistics indicate losses, expressed as mortalities and measured, most often, overwinter, ranging from 7 to 50% with large differences between countries (Table 2) (EFSA, 2008).

Member State	2006			2007		
	Hives	Beekeepers	Mortality (%)	Hives	Beekeepers	Mortality (%)
Belgium	110 000	8 600	-	-	-	-
Cyprus	41 478	707	-	40 533	712	-
Czech Republic	525 560	46 647	10	520 084	48 919	20
Denmark	80 000	4 100	15	-	4 100	7
Estonia	48 000	7 000	8 - 10	48 000	7 000	8 - 10
Finland	53 000	3 300	9.3	54 000	3 200	10.2
France	1 324 565	66 924	808*	1 243 046	65 050	142*
Germany	700 000	82 000	13	710 000	82 000	9
Greece	1 380 000	23 000	-	1 380 000	23 000	-
Hungry	923 103	15 764	-	897 670	15 320	-
Ireland	20 000	2 200	-	20 000	2 200	-
Italy	1 083 266	75 000	30 - 40	1 100 000	55 000	40 - 50
Latvia	62 000	3 300	-	70 000	3 400	-
Lithuania	100 000 - 120 000	11 000	-	100 000 - 120 000	11 000	-
Luxembourg	5 637	369	16	5 300	358	20
Netherlands	80 000	7 500	26	80 000	7 500	15
Norway	70 000	3 500	10.6	70 000	3 500	-
Portugal	-	-	-	555 049	15 267	-
Romania	1 100 000	3 200	10	996 000	2 942	> 20
Slovakia	217 338	12 797	-	247 678	14 854	0
Sweden	105 000	13 000	18	110 000	12 000	12
United Kingdom	274 000	43 900	11.1	274 000	43 900	11.7

Table 2

European statistics concerning the number of hives, beekeepers and mortality rate of bee colonies for 2006 and 2007, from EFSA, 2008.

* mortality expressed in number of declarations, or for France, in 2006, 1.2 % of beekeepers declared mortality (808 / 66 924 = 0,012421) ; in 2007, 0.6 % of beekeepers declared mortality (142 / 65 050 = 0,002189).

Table 3

Losses in the honey bee reported for France from 2008 to 2010 (from ITSAP, 2011).

Year	Losses			Description of losses		
	%	95% CI	Death (%)	With drone cells (%)	Weakness (%)	Disease (%)
2008	29.2	26-32	50.1	15.6	28.1	7.2
2009	23.3	21-25	50.5	15.5	26.3	7.7
2010	26.8	23-30	56.2	13.2	25.5	5.1

Based on records from ITSAP (2011), in France, losses are quite constant since 2008 and range from 23.3 to 29.2% overwinter, the cause of which is often a natural death of the colonies, weakened by winter. No trend for an increase has been observed over the last years.

Studies, in particular multifactorial studies (see Chapter 4.5), indicate that losses of pollinators are likely to be caused by a combination of several pressures including habitat loss, climate change, diseases, beekeeping practices, invasive species and pesticides.

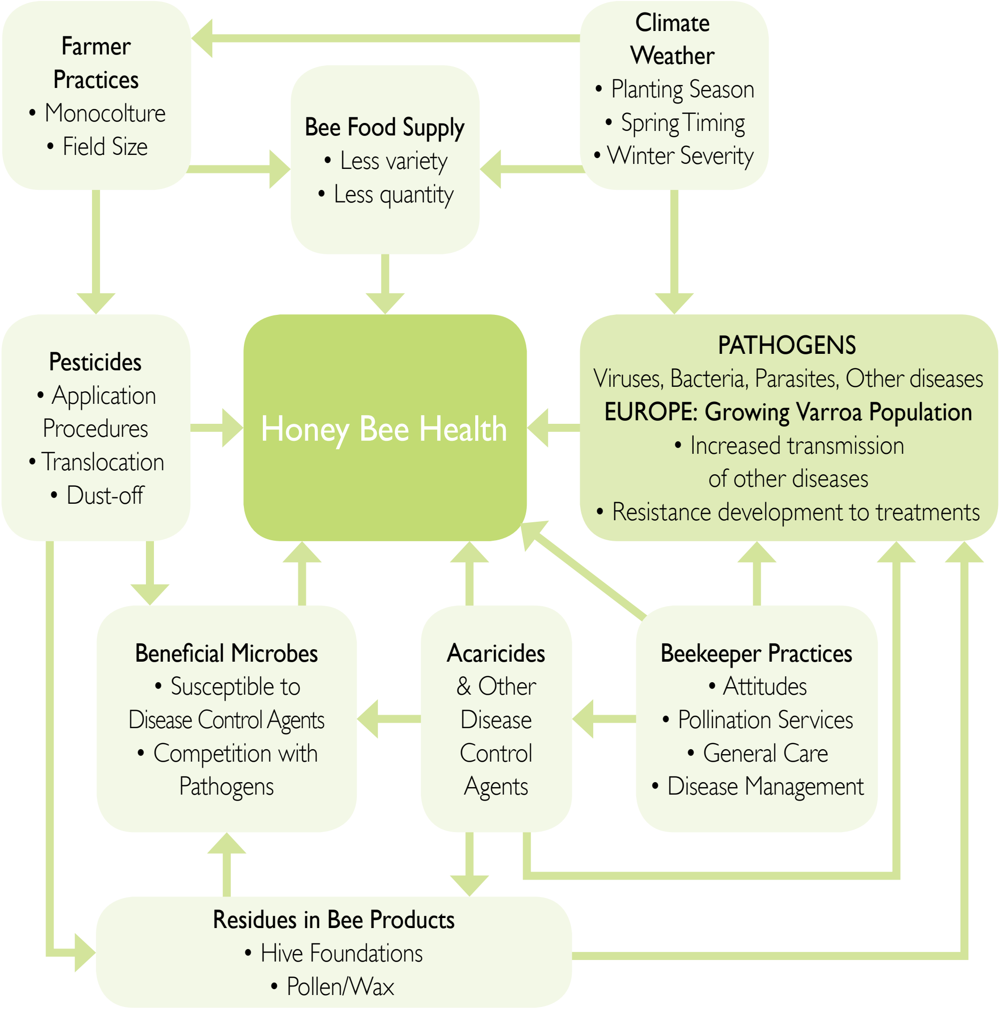


Figure 6

Interrelationship of bee health stressors (Adapted from Le Conte et al., 2010)

4.1. Pests and diseases

According to results of the scientific research projects, the main cause of honey bee colony losses is the *V. Varroa destructor* mite, which can be found in almost every apiary in Europe (see for example Genersch et al., 2010), Afssa, 2009 for a review). *Varroa destructor* is an external parasite that attaches to the body of *Apis* species, and breeds within the colony by laying its eggs within capped brood and feeding on *Apis* larvae. *Varroa destructor* is a known disease vector.

Depending on climatic conditions, the damage caused by *V. destructor* appears from autumn to early spring during the overwintering phase, leading to general weakening and often complete losses of colonies.

Varroa destructor in high level of infestation can be a direct cause of colony loss but it is also a vector of a number of viruses. Although bee viruses usually persist as unapparent infections and cause no overt signs of disease, they can dramatically affect honey bee health and shorten the lives of infected bees under certain conditions.

For example, significant infestations of colonies with the *V. destructor* mite and its association with Deformed wing virus *(DWV)* can seriously harm the health and productivity of honey bees. Of the 18 or so viruses identified as infecting honey bees, six viruses, namely, Deformed wing virus *(DWV)*, Black queen cell virus (*BQCV*), Sacbrood virus *(SBV)*, Kashmir bee virus *(KBV)*, Acute bee paralysis virus *(ABPV)*, and Chronic bee paralysis virus *(CBPV)* are the most commonly recorded around the world. It has been reported that *CBPV* is very widespread in Britain and can cause mortality in bee colonies particularly during long periods of confinement, e.g. due to poor weather conditions.

The availability of veterinary products to treat Varroa destructor and other pests is very limited, due to the small market for these products and the administrative burden for their approval. Often, products are approved in concentrations or formulations which lack efficacy against the disease or pest.

Even with proper management it is impossible to keep apiaries 100% free from *V. destructor* mites. Nevertheless, some strategies have been proven to be successful, the most efficient being collective action within an entire area with coinciding treatments, but require extensive knowledge in order to manage the possibilities and limitations of the different treatments.

Only a small number of approved *Varroa*cides are commercially available for beekeepers. Following a low efficiency treatment surviving colonies may again be in jeopardy if too many mites remain. There is a good chance of an unexpected mite population build up which, even if detected might be too late to treat. Treatments vary among countries and climatic zones. Certain treatments can only be used with success if there is a brood-free period in the colonies during winter, thus not applicable in all countries and climatic zones.

With regards to *V. destructor*, legally available treatments (i.e. treatments having been evaluated and authorized for use) are frequently not sufficiently effective to reduce *V. destructor* pressure. Furthermore, *V. destructor* mites have developed resistance against treatments in some regions. Organic acids like Formic acid, Oxalic acid, Lactic acid, etheric oils (preparations with Thymol, and other essential oils) and also synthetic substances (e.g. tau-Fluvalinate, Coumaphos, Flumethrin) have been proven to be potentially effective.

Also a gap is observed between conditions of use of effective treatments and their registration as veterinary products, as for example for formic acid, which is legally available in some EU countries as a preparation containing 60% of the active ingredient while it has been demonstrated that it is significantly more effective when formulated at 85%.

Depending on the climate and also the forage situation, such treatments may actually be the only solution for the rescue of colonies with high *V. destructor* pressure and thus there is a need for a real inventory of potential solutions and more research in support of registered veterinary treatments.

Thus there is an urgent need for more efficient, legally available, affordable treatments against the *Varroa destructor* mite, which is acknowledged as the main threat to honey bees in the analysis of the European Commission. As the market for such minor-use products is rather small only a few companies invest in the registration procedure. Due to the urgent need, registration procedures for new or improved methods developed by scientists should be facilitated and accelerated.

Apart from *V. destructor* and associated honey bee viruses, there are many other pests and diseases that may adversely affect colonies including *Nosema*, bacterial infections like European and American foulbrood, tracheal mites and fungal diseases. In contrast to *Varroa*, some of them, like *Nosema*, virus infections or foulbrood may damage colonies also during spring and summer.

It is also expected that within the coming years or decades, pests that are not currently present in Europe like the Small hive beetle *(Aethina tumida)* or the *Trolilaelaps* mites may appear and spread. The same scenario was previously observed with the *V. destructor* mite.

Two species of the microsporidian fungal *Nosema* parasite are widespread, *N. apis* and *N. ceranae,* both of which can be particularly harmful during overwintering of bee colonies. The epidemiology of some diseases, like viruses and also *N. ceranae*, which have been linked with several cases of large scale colony losses, is still not fully understood.

Ascribing a definitive cause to losses has also been made much more difficult by the variation of pathogen virulence and host susceptibility among different regions as well as by the different methods used by scientists in previous surveys and experiments (Neumann and Carreck, 2010).

It is important to note that the focus of the majority of disease research concentrates on *A. mellifera* bees. As a result, there exists a considerable knowledge gap concerning the incidence, effects, causes of and remedies for diseases in wild bees. Many wild bees have their own unique pests and diseases, e.g. the microsporidium *Nosema bombi* and the nematode *Sphaerularia bombi* in bumble bees.

4.2. Pesticides

Often the use of pesticides in agricultural cropping systems is discussed as a factor influencing bee health. Single events of poisonings by spray applications have been reported in many countries, usually due to misuse of products resulting in contamination of nectar and pollen (AFSSA, 2009; WIIS, etc).

4.2.1. Evaluating Exposure Potential

In discussing the exposure of bees, it is first necessary to consider if during the course of the use of any plant protection product bees are likely to be actually exposed, based on the details of the product and its pattern of use.

In some cases exposure of bees is negligible. For example, winter applications when bees are not flying, pre-emergence use of herbicides, wound treatments, rodenticide baits, indoor uses, use in glasshouses (where pollinators are not used), seed treatments according to modern standards, and granules (except where there is systemic activity) and products for dipping bulbs etc. are likely to lead to negligible exposure to bees and in such cases a risk assessment is not required.

A second consideration is the attractiveness of the crop plant. If the crop is not attractive to bees then again exposure will be minimal. However, other factors need to be considered such as the presence of other food sources in the treated area (e.g. flowering weeds, aphid honey dew). In general a crop is not attractive to bees when harvested before flowering, however, some crops that are intrinsically unattractive to bees or that are out of flowering season may also be visited due to extra-flora nectaries (e.g. field beans).

These initial steps are considered in current risk assessment schemes (e.g. EPPO, 2001). Under the recently published EPPO guidance separate pathways on the decision making tree are presented to cover the differences in exposure from sprayed and soil applied products. Likewise, this is covered in the US by the problem formulation stage.

In summary, the characteristics of standard scenarios to be considered when evaluating are the potential routes of exposure for honey bees and other pollinators from crop protection products, such as the method of application (spray or soil/seed treatment) and whether the product contains an active substance toxic to bees with systemic activity are described in Tables 4 and 5.

Table 4

Relative importance of exposure of honey bees and wild bees via various exposure routes of PPPs as spray applications

Exposure	Honey bees		Wild bees	
	Adult	Larvae	Adults	Larvae
Direct spray[1]	+++	-	+++	-
Spray drift[1]	++	-	++	++
Floral residues[2]	+++ to +	-	+++ to +	-
Nectar[3]	- to ++	+	- to ++	+
Pollen[4]	+ to +++	++	+ to +++	++ to +++
Foliar Residues[5]	+	-	+ to +++	- to +++
Water[6]	+ to ++	+	+	+
Nesting Material[7]	+	+	+ to +++	+ to +++
Exposure to Soil[8]	-	-	- to +++	- to +++

Notes: 1 When applications are made during bee activity to a flowering crop or when spray is allowed to drift onto adjacent flowering areas. 2 Exposure can vary due to flower turnover rate. 3 Depends on the systemic properties of the substance otherwise exposure is negligible. 4 Exposure can vary due to flower turnover rate and systemic properties of the substance. 5 Bees do not generally frequent leaves. An exception to this is for certain wild bees which may use leaves a nesting material. 6 Where spray leaves small temporary puddles or contaminated puddles in fields. Note: according to good practice applications should generally NOT be made rain is likely or recent. Bees general obtain their water from nectar but honey bees will use water for evaporative cooling of the hive. Beekeepers provide clean water for their bees. 7 Wax which is secreted by nurse bees in honey bee colonies may become contaminated due to transfer of residues. Nesting materials (such as soil) is used by both ground dwelling and cavity nesting wild bees. 8 Some spray may reach the soil; this mostly of concern to ground dwelling bees nesting in agricultural fields which is not their preferred habitat.

Table 5

Relative importance of exposure of honey bees and wild bees from various exposure routes of PPPs seed coatings, trunk injections and soil drench applications

Exposure	Honey bees		Wild bees	
	Adult	Larvae	Adults	Larvae
Dust (off field)	+ to +++	+	+ to +++	++
Nectar[2]	- to ++	+	- to ++	+
Pollen[2]	+ to +++	++	+ to +++	++ to +++
Foliar Residues[3]	+	-	+ to +++	- to +++
Guttation Water[4]	+	+	+	+
Exposure to Soil[5]	- to +	-	- to +	- to +

Notes: 1 Dust from treated seed may be deposited onto adjacent flowering areas when pneumatic drillers with air pressure applications are used. Exposure can vary to the quality of the seed coating and using of deflectors on seed drills. 2 Depends on the systemic properties of the substance otherwise exposure is negligible.3 Bees do not generally frequent leaves. An exception to this is for certain wild bees which may use leaves a nesting material if the substance has systemic properties. 4The occurrence of guttation droplets depends upon systemic properties, soil and air humidity and occurs at early (pre-flowering) crop growth stages. Beekeepers provide clean water for their bees. 5 Seed coatings are highly targeted and do not result in wide spread soil contamination. Soil drench applications only affect a small proportion of the total area. Exposure to soil is mostly of concern to ground dwelling bees nesting in agricultural fields which is not their preferred habitat.

4.2.2. Exposure routes

Poisoning incidents caused by pesticides usually lead to damage of varying degree in the colony, which in turn causes an economic loss but rarely the loss of damaged colonies. Nevertheless, it may be necessary to combine several colonies after an incident to enable complete recovery.

The most frequent causes of pesticide-related incidents are the misuse of products and/or ignorance of product label statements by farmers, combined with a poor communication with beekeepers, or disregard by the latter for good beekeeping practices.

4.2.2.1 Direct overspray and Spray Drift

The most important route of exposure to pesticides and by far most important cause for poisoning incidents is the exposure to direct overspray of bees in a treated crop and the uptake of contaminated nectar and pollen from flowering crops following inappropriate spray treatments, usually caused by a misuse or wrong application of a product classified as hazardous for bees. Likewise exposure can occur if the spray is allowed to drift at sufficient quantities to be harmful onto adjacent flowering areas where bees are foraging. Based on the outcome of the tiered approach in risk assessment, depending e.g. on the active ingredient and its toxicity, the formulation, the amounts used, the timing of application pesticides are classified into categories and use patterns which allow a bee safe use of the product.

4.2.2.2 Dust

Dust from seeds treated may be generated when pneumatic drillers with air pressure applications are used. Exposure can vary to the quality of the seed coating and using of deflectors on seed drills. Poisonings by dust drift occur not in the treated crop itself but in flowering crops nearby, which are contaminated by dusts. Before 2008, only a very limited number of single poisonings of bee hives on a small scale were reported in France and Spain. Recent bee-poisoning incidents by abrasion of insecticidal dusts from seed treatments and the release into environment, causing contamination of nectar and pollen were reported in Germany after sowing of maize in 2008 (Pistorius et al., 2009, Forster, 2009; Nikolakis et al., 2009), Austria (Girsch and Moosbeckhofer, 2011) and Slovenia.

Technical solutions for effective risk mitigation of dusts exist and are in place in many MS with positive results.

4.2.2.3 Guttation

The exposure of bees via uptake of guttation water containing residues of systemic insecticides such as neonicotinoids have been discussed and highlighted by Italian researchers. The level of residues in guttation droplets depends on different elements; the potential risk from different crops varies depending on the relative intensity and frequency of guttation events, crops, and the amount of active substance per seed as well as other factors.

Recent research data have demonstrated the issue of guttation is of comparably low importance compared to other exposure routes, and this can be easily avoided by beekeepers through the provision of clean water.

Guttation exposure can be very easily avoided by beekeepers through the provision of clean water in the vicinity of the hives.

Recent research data (Pistorius et al., unpublished; Keppler et al., 2010) have demonstrated the issue of guttation is of comparably low importance compared to intoxications by spray applications and indicate that in certain circumstances only small numbers of bees of a hive may be intoxicated, even if colonies are placed directly next to crops. The risk is likely to decrease rapidly within a few meters distance of the colonies to treated crops. The data indicate damage to colonies in worst case scenarios are on a low level. Effects on colony strength, brood development and overwintering have not been observed. Also, in incident reporting schemes e.g. in Germany (Pistorius, pers. comm.) no apparent poisoning incidents linked with guttation were reported by beekeepers or ascertained during subsequent investigation.

4.2.2.4 Sub lethal Exposure

When colonies are monitored for pesticides, often sub lethal amounts of different pesticides are detected. The compositions of different active substances and residue levels are strongly linked with the local situation, the agricultural structure and local patterns of pesticide use. Often, sub lethal pesticide residue concentrations found in nectar, pollen and bee bread are considered as a potential factor resulting in delayed adverse effects on bee health. However, in the results of studies so far available that were completely or partly dedicated to this topic, no correlation between sub lethal residues of pesticides in bee hives and colony mortality has been found (e.g. Genersch et al., 2010; Chauzat et al., 2009).

The role of multiple residues in sub lethal amounts, combinatory and synergistic effects and the impact on bee health needs further investigation. However, such research does not preclude the need to strictly respect the approved conditions of use for pesticides, which are designed to avoid exposure.

In this context, it should also be mentioned that in most studies on pesticide residues in bee hives among the compounds that were found most frequently and/or at highest concentrations there were acaricidal substances that were intentionally brought into the hives to control *Varroa destructor* (e.g. Chauzat et al., 2006; 2009; Genersch et al., 2010; Mullin et al., 2010; Johnson et al., 2010).

A number of countries already have defined conditions of use of insecticides or acaricides, to reduce or to prohibit spraying during flowering (e.g. EC, 2003; JORF, 2003). Thus in spite of the fact that multiple exposures do not necessarily imply direct or indirect effects, exposure avoidance should be the rule, rather than the exception.

4.2.3. Input from Existing Monitoring Studies on Bees

Monitoring systems can offer an important approach to the evaluation and analysis of bee health-related issues and their underlying causative factors. Although there is no universally agreed definition of a "bee monitoring" this term generally refers to surveillance systems where bee health in general or more specifically adverse effects of certain factors, is observed under practical conditions in the field.

Basically, two types of monitoring can be differentiated: on the one hand, **passive monitoring** systems (or incident reporting) where bee mortalities or other incidents are recorded and analyzed wherever they are reported; on the other hand, **active monitoring** systems where pre-selected bee colonies (or environmental factors which are thought to contribute to their health) are regularly surveyed.

In addition to this, some active monitoring may be undertaken to allow a look at multiple factors putatively contributing to bee mortality, in which case they are often called **"multifactorial studies"**. These approaches are described in Chapter 4.5.

With respect to causative factors, the EFSA report emphasizes the consensus of the scientific community about the multifactorial origin of the colony losses.

In Europe, there is a wide variety of monitoring and surveillance systems for bee mortality and bee health. An overview about these systems, with a focus on multi-factorial systems, was corroborated by a dedicated working group on behalf of EFSA (Hendrikx et al., 2009; EFSA, 2009).

Information about surveillance systems in 24 out of 27 EU MS that have set up respective systems was collected and evaluated. The analysis showed a very heterogeneous picture and high variability of most of the evaluated systems; therefore, the need is seen for improvement and for harmonization and standardization of surveillance systems over Europe.

With respect to causative factors, the report emphasizes the consensus of the scientific community about the multifactorial origin of the colony losses issue, and stresses the necessity of further research about the relevance of the potentially involved factors and their interaction. Factors mentioned as possible causes include beekeeping practices as well as environmental, biological (diseases and parasites) and chemical factors.

4.2.4. Incident Reporting and Investigations

Systems for reporting and analyzing bee incidents that may have been caused by agrochemicals are, according to a 2011 OECD survey, established in eight European countries (Denmark, Finland, France, Germany, Italy, Netherlands, Switzerland and the UK). The incident recording systems from the UK, Germany and The Netherlands are outlined in Thompson and Thorbahn (2009).

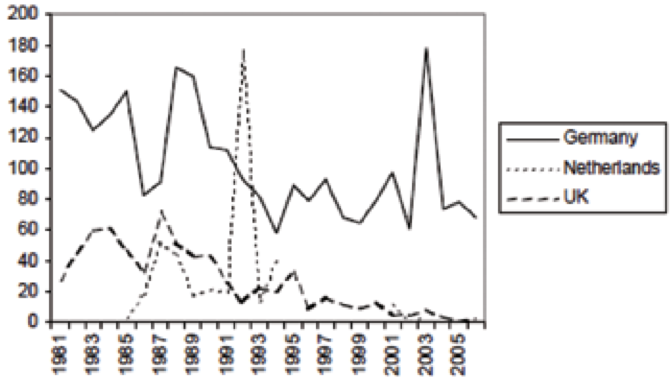
These surveys rely on voluntary reporting of incidents, usually by beekeepers. Reports are either declared through a written or computerized system, or by informing veterinary agents about mortalities (or diseases) that they have observed in their apiaries. This declaration system may or not require a mandatory declaration of their apiaries composition and location.

Reporting system show that numbers of pesticide-related bee incidents are generally declining in the monitored countries, which reveals that safe handling of pesticides has improved and that the regulatory systems are generally protective.

In the UK and Germany, beekeepers who suspect an incident possibly linked to a pesticide application can send samples to the authorities free of charge for further investigation. Plant protection services and also veterinarians are likewise involved in the field examinations of the incident and sampling procedure. Biological analyses, inspection for bee diseases and, if appropriate chemical analyses of the samples are conducted by the authorities. A similar system is implemented in France, led by the Ministry of Agriculture.

In other countries there are responses to specific incidents. For example in Greece association of colony losses with PPPs was considered as credible, and evaluated in 2009, and results were published in 2010 by Bacandritsos et al. (2010). However, in this study a single specific cause to the depopulation phenomena was not found, since multiple pathogens and detection of pesticides made it difficult to draw any conclusion.

The evaluation of incident reports shows that numbers of pesticide-related bee incidents are generally declining in the monitored countries, which reveals both that a safe handling of potentially critical products by their users has become more and more common, and also that the regulatory systems that govern honey bee risk assessment are generally protective (Thompson and Thorbahn, 2009).



Reported pesticide incidents for the UK and the Netherlands and reported incidents ascribed to pesticides in Germany during the period 1981 - 2006

Figure 7

Pesticide incidents in the UK, the Netherlands and Germany between 1981-2006 (Source: Thompson and Thorbahn, 2009)

4.2.5. Post Registration Monitoring Studies and other Product- or Crop-Specific Monitoring Approaches

These approaches constitute active monitoring and are aimed at checking that the conditions of use of some specific products are defined in such a way that the exposure of bees, and thus effects if any, are limited.

To date, the majority of these activities have focused on neonicotinoid seed treatment products in various crops. This reflects the fact that, since 2010, the EU Directive 2010/21 has modified the conditions of inclusion of neonicotinoids and fipronil as seed treatments, introducing the possibility for MS to implement monitoring to "verify the real exposure of honey bees […] in areas extensively used by bees for foraging or by beekeepers" if no sufficient data are available to make a sound exposure and risk assessment.

So far, none of the pesticide-related bee monitoring approaches found a clear connection between bee colony mortality as a general phenomenon and the exposure of bees to pesticides.

However, regionally limited bee issues with pesticides that were mostly related to specific local conditions and/or an inappropriate application of the respective product could be detected by monitoring approaches, whereby the underlying problem could later on be resolved by appropriate mitigation or stewardship measures.

However, since the available data sets on bee exposure and bee safety of most of the respective uses are rather comprehensive, not too many field monitoring activities related to the requirements of Directive 2010/21 have had to be launched so far.

France

One of the most extensive monitoring approaches is being conducted in France to survey the bee safety of the thiamethoxam seed treatment in maize. The implemented survey is aimed at evaluating the potential side-effects of the use of coated seeds on pollinating insects, and more particularly on the honey bee.

This survey was implemented over 3 years, covered 3 to 6 regions and involved several monitoring sites for each region. Sites had intensive maize cultivation grown from either treated or non-treated maize seeds. Apiaries were settled before sowing and remained until overwintering. Final data indicated a very low exposure of bees to residues of thiamethoxam over the entire growth period, and highlighted no product-related effect on colonies, even after several years of cohabitation.

Germany

A more small-scale approach with a similar use scenario of a neonicotinoid seed treatment product was conducted in 2008/09 by the University of Hohenheim in Southwestern Germany. Bee hives set up at different locations in a maize growing region where the crop was seed-treated with clothianidin were monitored during a season until the following spring; observations were accompanied by extensive residue sampling. No adverse effects of the treatment were found (Liebig et al., 2008; Liebig, 2009).

Other small-scale monitoring projects with a very specific focus have been conducted by the German Bee Institutes in 2010, to assess the potential effects of soil- and seed-applied neonicotinoid products (thiamethoxam, clothianidin) in maize and in other crops on exposed honey bee colonies. Although individual exposed bee hives displayed more or less pronounced mortality peaks on single days, no adverse effects on the colony level were observed.

Italy

Further activities to monitor potential effects of neonicotinioid seed treatment, particularly in maize, to honey bees, are being conducted in the framework of the ApeNet Monitoring in Italy. Latest results are reported by CRA-API (2009, 2010). The report does not refer to significant issues related to pathogens, but describes a couple of cases of acute poisoning by pesticides, most of them probably caused by incorrect applications. Moreover, mechanistic studies on pesticide exposure and intrinsic pesticide effects to bees are reported which are, however, strictly seen not a part of monitoring activities. In the previous reports (CRA-API, 2009, 2010) other useful data are reviewed based on descriptive monofactorial analysis of the potential risk and data monitoring in field. Mitigation are proposed. The project is ongoing and worth results are foreseen encompassing novel assessment of the health of the colonies by means of biomarkers and biochemical approaches.

Austria

Another monitoring project with focus on neonicotinoid seed treatment products is the MELISSA Project in Austria. In this project, particular attention is directed to the investigation of any damage to bees that is reported in association of growing maize. (Latest report: Girsch and Moosbeckhofer, 2011). According to preliminary results, the safety of neonicotinoid seed treatment products to honey bees can be sufficiently ensured when the prescribed security measures for the use of these products are complied with.

Switzerland

A monitoring project that consisted of a series of field studies was conducted in 2009 by the Swiss authorities, to investigate potential effects of a neonicotinoid seed treatment in maize due to dust during drilling, and due to guttation liquid, on exposed honey bee colonies (Bundesamt für Landwirtschaft, 2009). No increased mortalities or other adverse effects of the treatment were seen, either during sowing of the crop, which was conducted in compliance with the prescribed safety measures, or during the guttation phase of the crop.

Belgium

A monitoring of effects of Imidacloprid seed-treated maize to exposed bee colonies was conducted in Belgium by Nguyen et al. (2009). Sixteen apiaries located in the vicinity of treated or untreated fields were surveyed over one year. No adverse effects of the treatment could be found. The results indicated a significant correlation between the number of colonies per apiary and the mortality rates in the respective apiary. However, the mortality rate was inversely correlated with the surface of maize fields treated with Imidacloprid in the surroundings of the apiary, suggesting that the pesticide treatment did not interfere with bees' condition.

Overall, pesticide-related bee monitoring activities can be a helpful tool to assess potential side effects to bees on a large-scale level and under realistic field conditions, which can in particular be relevant in cases where the regular risk assessment has not been conclusive. Moreover, such monitoring approaches can reveal the necessity of stewardship measures for individual product types and test for the effectiveness of implemented stewardship measures.

4.3. Nutrition and Biodiversity

The availability, quantity and quality of nectar and pollen throughout the season are major factors for bee health. Bees feeding on a mixture of pollen from different plants are healthier than those fed only one type of pollen. Areas with high biodiversity are more likely to provide sufficient nutrition throughout the year, thus ensuring bee health. Changes in land-use, agricultural crop management, land abandonment as well as the loss of traditional farming and forestry practices, which have previously generated rich habitats, are some of the major causes for biodiversity loss.

De Groot (1953) showed that essential amino acids from protein digested are required in specific proportions to complete normal growth and development in honey bees. Tasei and Aupinel (2008) showing that bumble bee larvae fed with a poly-floral blend were heavier than larvae fed with monofloral diets of higher protein content.

The quality of pollen during development is important in determining the sensitivity of bees to pesticides. Bees fed on high quality pollen appear less sensitive to pesticides than those fed on lower quality or inadequate amounts of pollen or pollen subsitute during development (Wahl and Ulm, 1983). This observation suggests that nutrition affects the development of enzyme activities at specific life stages, with both the amount and the quality of pollen ingested in the first days of life affecting the sensitivity of both young and older adult bees. The effects of natural components in the diet was confirmed by Mao et al. (2011) who showed that the P450 mediated detoxification of acaricides may be affected by natural constituents in honey.

Alaux et al (2009) showed that protein feeding modified both individual and social immunocompetence in honey bees, but increases in dietary protein quantity did not enhance immunopcompetence. However, diet diversity increased immunopcompetence levels. In particular, polyfloral diets induced higher glucose oxidase activity compared with monofloral diets, including protein-richer diets. These results suggest a link between protein nutrition and immunity in honey bees and underscore the critical role of resource availability on pollinator health.

4.4. Habitat loss and fragmentation

For wild bees, habitat loss and fragmentation are of special importance. Many different wild bees are particularly dependent on special habitats and special wild plants compared with unlike managed honey bees, which fly longer distances and forage on a wider number plant species. Little information is available on how local management practices influence agricultural pollination (Richards et al., 2001).

Habitat loss is one of the biggest factors impacting bee declines (Brown and Paxton, 2010). To maintain health, foraging bees need a variety of sources of natural nectar and pollen to prevent nutritional deficiency and to strengthen immune defenses (Brodschneider and Crailsheim, 2010; Alaux et al., 2010; Pederson and Omholt, 1993). The increased numbers of large farms that grow one type of crop have resulted in reduced variety, quality, and quantity of pollen for bees. Bee foraging is further compromised by society's efforts to "neaten" landscapes by eliminating wild flowers and weeds in places such as lawns, parks, and farm boundaries.

4.5. Multi-Factorial Studies

Multi-factorial studies are the most dedicated approaches as they are designed to quantify the relative contribution of each of several parameters monitored in pilot apiaries implemented in a specific area, to any honey bee losses. An intensive sampling must has to be implemented so that colonies are monitored for health conditions and chemical residues (pesticides, veterinary products) in hive matrices and in some cases in crop matrices sampled on site. Such an approach allows robust statistical treatment of the data.

Multifactorial studies involve significant resources and are only rarely implemented. As a consequence, only a limited number of them have been undertaken so far.

A very extensive national long-term bee health monitoring project, the "Deutsche Bienenmonitoring" (German Bee Monitoring), is currently ongoing in Germany. In terms of the monitoring, more than 1,200 bee colonies from about 120 apiaries all over Germany are surveyed for their health and survival in connection with all environmental factors that may potentially affect bee health. Concurrently, the monitored hives were surveyed for pesticide residues.

The project was started in 2003, results of the first years were published by Genersch et al. (2010). Factors that were found to be correlated with colony losses include *V. destructor* infestation, certain virus diseases, age of the queen and weakness of the colony; no correlations were found with *Nosema* infestation and the exposure to pesticides.

A similar study was conducted in the years 2002-2005 in France. In total 125 hives from 25 apiaries distributed over the country were surveyed over the study period regarding their health and their survival, and pesticide residues were measured in several relevant hive matrices like pollen, beeswax and honey.

The results were published by Chauzat et al. (2006; 2009; 2011) and Chauzat and Faucon (2007). Although a relatively high number of pesticide residues were detected from a rather broad range of compounds, there was no correlation between pesticide residues in bee hives and colony mortality.

Another, less systematic overview of be mortality surveillance activities in selected European and North American countries and their results is provided in the Special Issue "Colony Losses" of the Journal of Apicultural Research (Various Authors, 2010). Of course, conclusions and focal points of the individual publications within this compilation are diverse; however, most contributors see *V. destructor* and other diseases as a key factor behind colony losses.

To date, the outcome of the reported multifactorial monitoring projects seems to suggest that the parasitic mite *V. destructor* is the main causative factor involved in honey bee colony mortality in Europe; about this conclusion there seems to be consensus in the vast majority of the scientific community.

Nevertheless, most researchers also agree that the problem is not caused by *V. destructor* alone, and assume a multi-factorial origin of the observed colony losses. Other involved factors include a multitude of diseases and parasites (their relative importance is controversially debated); hive management and beekeeping practices, climatic factors, queen health issues, nutritional problems, loss of genetic diversity, and environmental factors like the structure of modern agricultural landscapes. Pesticides are listed by many authors as a potentially contributing factor, but there are only few investigations that claim to have found concrete evidence for a key role of pesticides in bee losses, with the exception of incidental poisoning events that are mostly caused by misuse or abuse of insecticidal products.

CHAPTER 5. LEGISLATIVE FRAMEWORK ON RISK ANALYSIS RELATED TO BEE IMPACT

Modern crop management practices have the dual tasks of increasing crop production whilst ensuring proper control of pest populations and diseases through the use of PPPs. The pressures to ensure bee safety have resulted in legal requirements in the EU to assess the impact of PPPs on the agricultural environment, including pollinating species such as honey bees (EC, 2009; 2010).

The EU legislation on PPPs relies on two complementary texts that aim at ensuring a high level of protection (protection goals) of humans and the environment. For pollinators protection goals may be summarised as:
1. Protection of pollination services provided by honey bees and wild bees
2. Protection of production of honey and other hive-products
3. Protection of pollinator biodiversity (primarily wild bees)

5.1. Risk Assessment for Bees

The new Regulation 1107/2009 includes a requirement for honey bee *(Apis mellifera)* risk assessments to be undertaken for all pesticides where bees may be exposed. This is not a recent development. From early in the history of regulatory testing, pollinators have been identified as a key group of organisms to be protected from side-effects of pesticides.

Since then a number of guidelines and guidance documents to ensure standardized testing methodologies for chemical substances have been published in Europe by organizations such as the Organization for Economic Co-operation and Development (OECD) and the European and Mediterranean Plant Protection Organization (EPPO).

The evaluation of the impact of pesticides on bees has been done for many years in Europe.
The Regulation 1107/2009 on pesticides includes now a specific requirement for risk assessment on honey bee (Apis mellifera) where bees may be exposed.
This provision was covered by the approval procedure also under the previous framework, Directive 91/414.

These documents provide standardized methods for honey bees as well as for non-target vertebrates, invertebrates and plants to fulfill the regulatory needs in terms of environmental screening for the side-effects of chemicals, from the laboratory to the field (*http://www.oecd.org/home, http://www.eppo.org/, http://ec.europa.eu/dgs/health_consumer/index_fr.htm, http://www.efsa.europa.eu/*).

Early pesticide approval schemes, for example in the UK, relied solely on the toxicity of the pesticide to honey bees, but it became apparent that both toxicity and exposure are important in determining actual risks in the field. Since the 1980's risks to honey bees from exposure to PPPs have been assessed using standardised schemes such as EPPO standards PP 3/10 (2) (OEPP/EPPO) and these were incorporated into the Directive 91/414.

These schemes rely on initial toxicity studies conducted in the laboratory, followed by semi-field studies, and finally field studies. The need for further higher tier studies is determined by a risk evaluation at each stage. Based on the significant differences in the exposure scenarios, sprayed PPPs are assessed separately from systemic applications of pesticides which may be applied as seed treatments, soil drenches, granules or as a pre-blossom spray.

The scheme for sprayed products (both non-systemic and systemic pesticides applied directly to bee-attractive crops), has been in place for nearly 20 years whereas that for systemic pesticides applied as granules, seed treatments and soil drenches or as pre-flowering applications has only recently been formally developed (EPPO, 2010). However, national registration authorities have previously undertaken risk assessments based on the same principles as proposed in the EPPO risk assessment scheme, e.g. for the authorisation of Thiamethoxam, Fipronil and Clothianidin Imidacloprid.

Conditions of use of pesticides are, in the majority of cases, designed in a way to limit the exposure of humans and the environment. In addition, Directive 2003/82 lays down a set of warning sentences, to be assigned based on the outcome of the evaluation of risks, and aiming at describing conditions to limit exposure and transfers of products and their residues (EC, 2003; EC, 2011b).

In a regulatory context, the risk assessment that has been developed for "bees" essentially relies on the regulatory tests performed on the honey bee (EC, 2010). In part because of their role in pollination but also their close relationship with man which raised their profile over other pollinators.

Development of test guidelines has focused on this species because of practical reasons related to "ease of rearing" (or "amenability as a test species"), and because it was identified as an indicator species, due to its relationship with a large number of crop and non-crop plant species (EPPO, 2001; 2003; 2010).

Although not specifically directed at pollinators it must also be remembered that tests of the effects of PPPs on other "non-target" arthropods (e.g. predatory mites, parasitic wasps, lacewings and ladybirds as particularly sensitive surrogate testing species) are also undertaken. The regulatory risk assessment for these non-target arthropods is intended to cover non-*Apis* pollinators as well.

5.2. Risk Assessment for Other Pollinators

In Europe, the honey bee is, apart from humans, the only organism for which a dedicated risk assessment is performed at the species level. Other non-target organisms are assessed at the level of taxonomic or trophic groups (i.e. fish, aquatic invertebrates, algae, aquatic plants, birds etc.).

As a consequence, the knowledge of the possible impact that pesticides may exert on the honey bee is detailed and documented than for other pollinating species. This calls for ever more informatios that, in many cases, relates more to pure mechanistic processes than to ecotoxicological assessment connected to protection goals. Another consequence is that the extrapolation of the outcome of the risk assessment to other pollinating species is dependent upon the nature of the information produced in the dossier.

Further developments of the testing methodologies need to take into account the added value of the supplementary information to the risk assessment.

In the case of pesticides of low concern (for which a conclusion may be drawn based on a first tier risk assessment and for which no particular impact is expected, from the pesticides' properties and mode of action on invertebrates in general) there is a strong possibility to also conclude that this implies a low concern to other pollinators.

For pesticides for which higher tier studies have been deemed necessary to complete the risk assessment, further extrapolation needs to be appropriately addressed and the need for bridging studies is a case by case issue.

5.3. Pesticide Approval Process

EC Regulation 1107/2009 and prior to this text, Directive 91/414, require demonstration that the placing of individual PPPs on the market and their use complies with the mentioned protection goals. The registration of pesticides relies on a strict set of rules (see a summary of the procedure in Annex III) for the constitution of dossiers and risk assessment which allow, for each use, to define conditions of use that ensure that protection goals are met. Risk management measures may be recommended, which are product-specific and shall appear on the labelling.

Directive 2009/128 (the Sustainable Use Directive) extends the set of measures that should improve the safety level over the whole process, from the training and certification of users to the control of application machines and the development of effective alternative methods.

The text notably offers the opportunity for an improved "professionalization" of users, a better knowledge of cropping systems and crop management tools in relation to actual needs, and the capacity to appreciate the benefits in terms of pesticide risks in cropping systems through the development of global indices.

CHAPTER 6. RISK MANAGEMENT AND STEWARDSHIP CONSIDERATIONS FOR PROTECTING POLLINATOR HEALTH

In 2009, the European Food Safety Authority (EFSA) published their report on the phenomenon of bee mortalities across Europe describing a multi-factorial suite of bee health pressures. Due to the complexity of this situation and the scientific agreement that a single answer to the many problems impacting bees is not possible, efforts to elucidate solutions continue.

Scientists have narrowed the list of suspects that may be causing bee deaths, and research now focuses on the interaction of several factors. Even without definitive answers, we currently know enough to take some positive steps towards protecting pollinators.

6.1. Habitat, Nutrition and Health

One solution to mitigate dietary and habitat pressures encountered by pollinators is the use of multifunctional landscaping (*www.opera-indicators.eu*). This is the basis of the successful Operation Pollinator® (*www.operationpollinator.com*) programme, for example. An international biodiversity program designed to boost the number of pollinating insects on commercial farms by creating food source habitats and increasing biodiversity, Operation Pollinator provides farmers with tools to create specific habitats, tailored to local conditions and native insects, along with innovative pesticide use practices and agronomic advice designed to benefit pollinators. This has resulted in an increase in the incidence and range of bee species, butterflies and other insects.

Another program that aims at the development of measures to enhance pollinator biodiversity in the modern agricultural landscape and to test the effects of these measures has been started in 2010 in Southwestern Germany (Maus pers. comm.). First results are to be expected in 2012.

Another recommended design element is the use of buffer margins next to crops to reduce both spray and dust drift onto neighboring fields and habitats, thereby protecting biodiversity and food sources.

Attempts to manage pollinator dietary challenges with supplements have had limited success and are considered inferior to the floral resources of habitat. It is clear that simply leaving the edges of a field planted in a few species of unmanaged grasses affords little environmental return for pollinators. Planting forbs and native flowering plants in buffers provides floral resources for pollinators.

6.2. Agricultural Practices

Pesticides play an important role in controlling insect pests, weeds and diseases on farms and in urban landscapes. Pollinators are attracted to a variety of blooming flowers on crops, trees, shrubs, weeds, and native vegetation and may visit both crop and non-crop plants for nectar and pollen throughout the growing season. Following pesticide label directions is the best method to protect pollinators and in parallel, failure to properly follow use recommendations is one of the biggest factors associated with significant, isolated, effects on bee populations.

Many recommendations for proper pesticide use and good stewardship practices have been developed to help mitigate the potential for harm to pollinators. These publicly available guidance documents offer steps to protect pollinators and their food sources, water and habitat. Below are some key elements.

An important activity is going on in the Pesticide Effects on Insect Pollinators working group of OECD, where an inventory of risk management measures is drafted. This inventory lists the measures being implemented in EU member states to reduce the risks to pollinators/honey bees, and gives specifications on their regulatory/voluntary status. When available it will provide a source of valuable information on methods and measures to protect pollinators.

As general recommendations on principles to be followed in agricultural practices to protect bees and pollinators, we can identify the following categories:

Minimize off-site drift of sprayed materials

- Establish appropriate buffers (no-spray zones) between treated areas and pollinator habitats or hives.
- Check the weather forecast before application and be mindful of changing weather conditions during application in order to minimize drift.
- Do not spray when wind is blowing toward pollinator habitats or areas where hives are stored.
- Calibrate the sprayer often, checking individual nozzle output and pattern.
- Always shut the sprayer off when making turns at field ends or gardens, near ponds or other sources of water that may be used by pollinators.
- Consider sprayer technologies that reduce drift. Use low pressure or low-drift nozzles, if possible.
- Vapor drift can occur after applications of certain pesticides. Spray during cool temperatures to minimize vaporizing action of the product.
- Minimize vaporization during application by avoiding nozzles with fine spray classification, where possible.

Minimize off-site drift of seed treatment materials

- Always use high-quality seed that is free of excessive dust.
- Use an appropriate coating system that minimizes abrasion of the seed treatment.
- Do not apply additional seed treatment products to previously treated seed.
- Do not leave empty bags or containers in the field.
- Avoid transfer of dust from the seed bag into the seed planting (drilling) machine.
- Drill at the recommended seeding rate.
- Employ a dust reducing device (deflector) on the drilling machine.
- Check the weather/wind forecast before application and be mindful of changing weather conditions during drilling to minimize dust drift. Do avoid drilling under windy weather conditions.
- Cover spilled seeds with soil

Understand Pollinator Visitation Habits

- Bees and other pollinators are most at risk of exposure during application when crops, weeds or other vegetation are blooming. To avoid exposing pollinators, strictly observe the application timing on the label relative to the blooming stage of the crop and other blooming plants in the area. In addition, realize that the application window (period when the timing is right) may be reduced due to factors such as extended crop bloom, blooming of nearby crops and wild areas or unfavorable weather conditions.

Cooperate and Communicate with Others

- Cooperation and communication among growers, applicators and beekeepers greatly increases the likelihood of protecting managed pollinators, their hives and habitats.

Examples of Pesticide Use Recommendation and Guidance Materials for Protecting Pollinators

1. Pollinators and Pesticide Stewardship (2010). Coalition for Urban/Rural Environmental Stewardship (CURES). *http://www.curesworks.org/home.asp*
2. Protecting Pollinators: How and Why Pesticide Applicators Can Protect Them *http://www.pollinator.org/PDFs/NAPPC.pesticide.broch.Applicators17.pdf*
3. Best Management Practices (BMPs) For Beekeepers Pollinating California's Agricultural Crops (2011). C. Heintz, M. Ribotto, M.Ellis, K.Delaplane. Jointly published in the *American Bee Journal* and in *Bee Culture*. *http://www.beeccdcap.uga.edu/documents/bmpcalagr.html*
4. Trees, Pollinators and Responsible Pesticide Use - *http://www.pollinator.org/Resources/MinnBroch.final.pdf*

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Increasing demands for food and fiber have led to important changes in the agricultural landscape over the past centuries. The possible impact of the sustainable cohabitation of agricultural production with the fauna inhabiting agro-ecosystems, which includes pollinators, has been a subject of concern for the past decades. This has led to schemes and programs with the intent on protecting and measuring the impacts on these fauna.

With regards to the honey bee, a number of incident reporting systems, active monitoring with pilot hives, multifactorial studies, field post registration studies dedicated to pesticides and field research projects have been implemented over the past 20 years. Together these contribute to current understanding of honey bee health status across Europe. Although significant gaps still exist in our knowledge, they have enabled a better picture of honey bee health status throughout Europe and abroad. The data generated thus far indicate the following:

- the honey bee can cohabitate with modern agricultural practices provided that necessary precautions are taken to maintain viable food resources for bees and that practices that may cause adverse effects are avoided;
- honey bee health, evaluated through indicators such as overwintering mortality, presence of pest and diseases or honey production, relies on many factors, such as the availability of veterinary products to the local market;
- indicators such as the number of apiaries, beehives or beekeepers inform on the status of bee health on a more limited way. This is because they are strongly affected by local and global economies, numbers of professional beekeepers and market prices;
- impacts on honey bee health may have various origins and have thus been qualified as "multifactorial". Agricultural practices, if they lead to food shortage for bees, poor food resources or to inappropriate pesticide applications or misuse (e.g. not following the conditions on the label) may contribute to the weakening of bee colonies which may become more vulnerable to pests and diseases;
- attempts to rank factors which may impact bees indicate the following order: pests and diseases; habitat loss; land fragmentation; loss of nutrition sources; poor beekeeping and agricultural practices and poisoning. This order is to be interpreted with caution as it may vary between and within countries;
- declines comparable to those caused by CCD in the US have not been observed in Europe,
- the design of agricultural landscapes and the implementation of practices that account for the presence of pollinators is effective to limit the impact on population to a negligible level;
- veterinary compounds are missing or insufficient to help beekeepers eradicate the most important pests from apiaries; similarly, little support is given to collective actions against pests and diseases;
- there is a general lack of communication among actors in the agricultural landscape (e.g. farmers and beekeepers) and between them and those involved in scientific and regulatory roles. Modern agriculture and beekeeping demands better technical knowledge and skills including input from science or regulators in risk management which is often biased by limited communication and even mistrust.

The case of wild bees may be considered to be very similar to that of the domesticated honey bee, albeit far less well documented. Monitoring data are very limited and the health status of wild bees can be determined from either yields of related cultivated crops or from the finding of the few survey programs which are available.

Recommendations

The recommendations below concern all those involved in agriculture, bee keeping regulatory authorities and research. It is essential that these recommendations are communicated to all as the effectiveness of the actions will rely on their common effort to implement them.

Agricultural landscape

- ✓ Habitat conservation and management, considering the needs of pollinator species is a key aspect in reversing the decline. Solutions such as management of flower strips and planting of alternative forage plants need to be incentivized so that farmers and other non-agricultural actors manage the environment to promote on-farm or non-farm biodiversity.
- ✓ Provision of access to pollen and nectar in both cropped and non-cropped areas of agricultural together with the provision of nesting sites for wild bees are key elements for pollinator and bee health.
- ✓ Migratory beekeeping can contribute to meeting nutritional needs of healthy bees; hence the policy needs to promote it.
- ✓ There is a need to improve communication between farmer/grower and beekeepers, to avoid incidents related to pesticide applications.

Beekeeping

- ✓ Modern beekeeping is a highly complex activity. Training should be promoted and proposed on a regular basis to support the development of beekeeping activity.
- ✓ Efficient treatments for bee pests need to be urgently made available. The authorization process should be adapted and possibly be simplified to allow an accelerated availability and the possibility to adapt recommendations of uses based on advances in science. However, the approval and use of new and modified treatments should also be implemented with the associated training on the correct use of such treatments.
- ✓ Resistance developments in pests should be considered in monitoring programs as well as through dedicated research.
- ✓ Communication on existing beekeeping manuals and guidelines for beekeeping practices and hygiene procedures should be a priority. The implementation of the practices can be significantly stimulated by the development of beekeeping professional standards.

Monitoring

- ✓ Monitoring schemes are the most appropriate tool to analyze honey bee colony losses, and to identify the factors that can contribute to bee health and bee mortality. Monitoring actions should be promoted throughout the EU, based on an analysis of the input and learning from the current national monitoring and surveillance systems in place. In addition, methods for ensuring feedback from monitoring regarding risk assessment as in the case of pesticides, and risk management should be developed.
- ✓ Methods should be adapted for the monitoring of wild bees with the purpose to generate data to allow for comparable assessment. Equally methods to allow the assessment of the efficacy of any habitat and biodiversity program would be useful.

Pesticides

- ✓ Significant effort and advancements have been made in the area of regulatory testing and on risk assessment. Indeed honey bees benefit from one of the most detailed risk assessment system as they are evaluated at the level of the species and over time frames that may possibly cover several years. Risk assessment alone cannot cover all aspects of the issues surrounding bees. Improvement in risk assessment and the level of protection they provide now has to rely on the feedback and validation from surveys and monitoring where specific aspects like crop rotation or interactions with other stressors may be appropriately addressed.
- ✓ Where risk management options are required for the safe use of certain pesticides these should be better communicated among and within EU Member States so that knowledge and technical improvements may be shared and implemented quickly.
- ✓ The efficacy and use of on-farm habitat management schemes as global risk management options for honey and wild bees should be evaluated and communicated.

Economy

- Greater emphasis should be put on ensuring a better functioning of the internal EU market for apicultural products. Honey producers should be better placed to take advantage of the opportunities offered by the internal market.
- Economic support for beekeepers is considered to be essential so as to compensate their high costs in controlling and eradicating bee pests. Higher availability of medicinal products for these pests will also decrease their relative costs for the producers.
- Structurally, the EU has to take bold steps in promoting professionalism within beekeeping as opposed to amateur beekeeping. This will provide a series of benefits in terms of the application of good beekeeping practices, welfare and health of bees, productivity and profitability of beekeeping.

Research

- Continuation and strengthening of research activities, including those on bee pests, diseases and on pesticides, and their potential interactions, are particularly important so as to develop the right measures to avoid any potential negative impacts or to limit and manage impacts to acceptable levels.
- Research activities should also be more balanced between wild bees and the managed bees. The ecology of wild bees, their sensitivity to pathogens and other stressors should be investigated to ensure that the agricultural practices and risk management measures that implemented also allow for their adequate protection.

Annex I

Preliminary Synthetic Results of the Greek Research Project: Effects of GMOs, Neonicotinoids and Air Pollution on Honey Bees

COLOSS Network

The honey bees act as bio-indicators of pesticide and environmental pollution in two ways: a) directly, as they signal high mortality rates under the presence of toxic molecules and b) indirectly via the residues in honey and pollen. One of the goals of this study was to determine the residual effect of the neo-nicotinoid Imidacloprid on the honey bees.

In order to determine the residual prevalence of Imidacloprid on the bee tissue, honey and pollen, a number of honey bee colonies were placed in treated cotton fields (in Giannitsa area) just at the beginning of blooming, as well as in non-treated fields in Chalkidiki (urban area). The analyses of imidacloprid residues were conducted in the Laboratory of Pesticides Toxicology, at Benaki Phytopathological Institute. The determination of Imidacloprid was achieved by Liquid Chromatography coupled to Mass Spectrometry operating in tandem mode (HPLC-ESI-MS/MS, positive mode). Extraction and cleanup were based on a modified QuEChERS method, involving Solid Phase Extraction (SPE) step for the purification of analyte from the matrix (bee, honey, pollen) interference. Briefly two transitions were selected; one for the identification (256 to 175 amu) and one for quantification (256 to 209 amu) of imidacloprid. The Limit of Detection (LOD) of the analytical method was 1.26 ng/g. Recovery experiments were performed in all matrices with mean value of 60%. Imidacloprid was not found on the bees' tissues, honey and pollen from untreated fields. However, it was detected in honey bee tissue (8.79 ng/g); in pollen (5.68 ng/g) and in honey (7.42 ng/g) 25 days after the colonies were placed in treated cotton fields.

It is apparent that honey bees as well as honey bee products can be used as bio-indicators of environmental pollutants. The accumulation of pesticides in bees as well as on bee products cannot be excluded.

Annex II

Abandonment of apiculture as a major cause for decline

Aizen MA, Harder LD. 2009 conclude that that declines in the stock of domesticated honey in some European countries reflected on-going abandonment of apiculture in the face of competition from cheaper imported honey. This is supported by the data on the both the increased efficiency of honey production worldwide and the faster growth in hive numbers in Asia, Africa and South America than in North America and Europe.

They point out that, honey bee pests have to be considered as an extra economic burden borne by beekeepers, which includes the costs of miticides, replacing hives, reintroducing queens, etc. However, these costs may be relatively minor compared to the cost of human labour.

Their analysis explains the important contribution of economic globalization and protectionism to both the positive global trend and spatial variation in the growth of the global stock of domesticated honey bees as well as explaining the decrease in European and North American stocks.

Study case: FRANCE

(Source: *"Weakening, collapse and mortality of bee colonies"* AFSSA, 2009)
There are around 65,000 beekeepers in the French beekeeping sector, both professional and amateur.

The number of hives per apiary varies depending on the beekeeper's status. The data on the registered beekeepers reveals a high dominance of amateur beekeeping with less than 30 hives per apiary, corresponding to 97.4% of a total 68,263 beekeepers. There are around 1,762 professional beekeepers with more than 150 hives per apiary representing 2.6% of beekeepers. The average number of hives per professional beekeeper is 338.

Analysis of data reveals a decrease of around 15,000 beekeepers between 1994 and 2004, mostly from the amateur category.

A decline in the number of hives per apiary has also been observed for the latter group, contrary to the increase in number of hives observed for professional beekeepers. This is probably intended to compensate for the decrease in production associated with colony loss.

According to Abeille & Cie review, the number of French hives has apparently increased significantly in recent years: "an increase of more than 300,000 colonies has been observed over the last 3 years for the 25 countries of the European Union. France stands out with an increase of 200,000 colonies" (Bruneau, 2007). An overall reduction in French honey production was observed between 1996 and 2004. Honey production varied between 29,000 and 30,000 tons in 1996 and 25,000 and 26,000 tons in 2006 (Clement, 2006; GEMONIFLHOR, 2005). The 2004 honey production study shows:

- variable production levels depending on the beekeeper's status (professional beekeepers have a higher yield through optimised beekeeping techniques: transhumance, follow-up of honey flow, etc.);
- a fall in production compared with previous years, explained by a high winter mortality and climate change (particularly drought).

Production costs per apiary vary and increase with the number of hives. They are around €25 per hive for an apiary with fewer than 150 hives and €53 per hive for apiaries with more hives.
This paradox is undoubtedly tied in with the differences in expenditure consideration depending on the size of apiaries.

Study case: Poland

As reported by Semkiw and Skubida 2010, economic factors, such as high production costs, low sale prices and technological problems have marked the evolution of colony numbers in the past years in Poland. Moreover, shifts in the number of honey bee colonies had a direct relationship with the reduced number of apiaries.
Production costs and shrinking margins have negatively affected the number of people interested in beekeeping. An additional market pressure is the low producer prices offered by retailers. The unbalanced distribution of profit margins between the retail sector and producers has exerted a negative effect on the number of beekeepers.
An important factor determining the perspectives of the polish beekeeping is the age distribution of beekeepers. Approximately 60% of the beekeepers were found to be over 50 years according to the data of the national beekeeping association. The structure of apiaries shows a predominance of small and medium ones with up to 80 colonies. In 2009, Professional beekeepers (more than 150 colonies) in Poland owned only 5.32% of the total number of colonies. The small size makes the apiary even more sensitive to the market and economic variations.
Interestingly, it has been observed that professional beekeeping generates higher production costs than the low scale amateur one. This is due to the additional investments needed for better hives and additional costs related to transport, medicine, replacement of queens, etc. However, the level of production clearly was higher than that for small scale production and very often below the profitability ceiling. The market price for honey and the competition of cheap imports are considered one of the major obstacles in the development of beekeeping. Poland being a net importer of honey, sources the majority of its imports from China and Ukraine at prices between 1200 Euro/ton and 1800 Euro/ton.

Study case: Romania

Romania ranks 4th in Europe in the production of honey and bee products. In the same time, Romania ranks last in Europe for the annual consumption per capita, with an average of 0.15 - 0.17 kg / person / year, given that consumption in Germany is about 1.5 - 2 kg per person annually.

Regarding the evolution of the number of bee colonies in Romania, one can see that in the last 10 years the number of bee colonies doubled at the national level.

Table 1

Source – Ministry of Agriculture and Rural Development

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010 estimation
Colonies (1000)	614	745	781	839	888	920	975	1.086	1.109	1.110	1.280

Due to climatic conditions, bee products here are of high quality. The amount of honey produced annually nationwide is 50%, 35% and 15% polyflower, acacia and lime honey respectively. Pollen production is at 50-60 tons / annually and may reach 100 tons. Pollen is produced mostly in centre and the north part of the country.

Table 2

Source – Ministry of Agriculture and Rural Development

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010 estimation
Honey production - tons	11.746	12.598	13.434	17.409	19.150	18.195	18.195	16.767	20.037	21.500	23.700

The bee farm structure, as reported at 01.01.2010 is dominated by small apiaries with less than 50 colonies amounting 56.56%.

Table 3

Source – Ministry of Agriculture and Rural Development

Farm dimension (colonies)	Colonies	%
1 - 50	627.823	56,56
50 - 150	265.676	23,94
more 150	216.501	19,50
Total	***1.110.000***	***100***

The main markets for honey and bee products are the European and North American ones. Over 60% of honey production is exported to Germany, UK, Italy, France, Austria, USA, Canada and Japan. Although very popular in terms of quality on external market, honey produced in Romania is valued at lower prices since European processors prefer wholesale acquisition system and the prices offered very often do not cover beekeepers' costs.

Annex III

A summary of the procedure for the approval of PPPs.

The procedure used for the approval of a PPP is rather complex. Main steps to be followed in a usually 5-8 years procedure are:

- ✓ submission, by the product owner, of a dossier fulfilling the data requirements established by the legislation for active ingredients and formulations demonstrating the compliance to decision making criteria having been established on a risk-based approach
- ✓ the dossier is subject to a peer review that consists in an in-depth evaluation, by scientific experts in Member States, of the content of the studies and of the risk assessment performed for each use and product
- ✓ conclusions of this evaluation are the basis for decision making
- ✓ active ingredients are approved at the European level
- ✓ in Member States, further evaluations are undertaken for each of the formulated products containing the active ingredient and authorisations may be granted for the uses that comply with decision making criteria for acceptable risks.

The evaluation aims at demonstrating that the product, under the conditions of use defined as Good Agricultural Practice, is sufficiently effective and has no immediate or delayed harmful effect on human health, and the environment (EC, 2009a).

This evaluation is based on a detailed description, based on data, of the fate and distribution of the product in all environmental compartments, its impact on human health and non-target species and its impact on biodiversity and the ecosystem. Each use of the product is evaluated so that it is thereafter defined to bring the minimal application rate at optimized application frequency for an effective protection of plants with no impact on human health and the environment.

Decision making criteria have been developed to ensure acceptable risks to humans, i.e. the operator, worker, bystander, consumers and the environment, i.e. water quality (surface-and groundwater, would they be used for drinking water or not), to organisms of the aquatic and terrestrial ecosystems that could be subject to transfer of residues after the application of the product.

This includes birds and mammals of agricultural ecosystems, invertebrate fauna including pollinators and the honey bee, non-target flora, soil micro-and macro organisms in the field and aquatic organisms of border water bodies.

Decision making criteria have been defined in relation to protection goals and specific criteria have been allocated to each of the protection goals listed above. Decision making criteria for pesticides are reported under Regulation 546/2011 under Regulation 1107/2009/EC (EC, 2010 and 2011a).

Pesticide Labelling – Warnings

These sentences provide the framework for risk management measures that are specific to each product and that will appear on its labelling. As an example, all plant protection products should be labelled with the following phrase, which should be supplemented by the text in parentheses, as appropriate: "*SP1: Do not contaminate water with the product or its container (Do not clean application equipment near surface water/Avoid contamination via drains from farmyards and roads*)." This phrase is of generic nature as it rather corresponds to Good Practice.

Additional phrases have been developed for the purpose of the protection of operators (SPo) and the environment (SPe), for which they propose risk management measures.

Those for pollinators are identified under SPe8: *Dangerous to bees./To protect bees and other pollinating insects do not apply to crop plants when in flower./Do not use where bees are actively foraging./ Remove or cover beehives during application and for (state time) after treatment./ Do not apply when flowering weeds are present./ Remove weeds before flowering./Do not apply before (state time)*. The phrase must be assigned to PPPs for which an evaluation according to the uniform principles shows for one or more of the labelled uses that risk-mitigation measures must be applied to protect bees or other pollinating insects. Depending on the use pattern of the plant-protection product, and other relevant national regulatory provisions, Member States may select the appropriate phrasing to mitigate the risk to bees and other pollinating insects and their brood.

References

1. Alaux C., et al., 2010. Diet effects on honey bee immunocompetence. Biology Letters. 6:562-565.
2. Alaux C., Ducloz F., Crauser D. & Le Conte Y., 2009. Diet effects on honey bee immunocompetence Biol. Lett. published online 20 January 2010doi: 10.1098/rsbl.2009.0986
3. Aizen M.A. & Harder L.D., 2009. The global stock of domesticated honey bees is growing slower than agricultural demand for pollination. CurrBiol. 19:915-8.
4. Aizen M.A. & Harder L.D., 2009. Geographic variation in the growth of domesticated honey bee stocks - Disease or economics? Communicative & Integrative Biology. 2:6, 464-466.
5. Aubertot J.N., Barbier J.M. , Carpentier A., Gril J.J., Guichard L., Lucas P., Savary S., Savini I. & Voltz M., 2005. Pesticides, agriculture et environnement : réduire l'utilisation des pesticides et limiter leurs impacts environnementaux, synthèse du rapport d'expertise, pp64
6. Bacandritsos N. et al., 2010. Sudden deaths and colony population decline in Greek honey bee colonies. Journal of Invertebrate Pathology. 105: 335-40.
7. Barnett E.A., Charlton A.J. & Fletcher M.R., 2007. Incidents of bee poisoning with pesticides in the United Kingdom, 1994–2003. Pest Manag. Sci. 63:1051–1057
8. Batary P., Baldi A., Sarospataki M., Kohler F., Verhulst J., Knop E., Herzog F. & Kleijn D., 2010. Effect of Conservation Management on Bees and Insect-Pollinated Grassland Plant Communities in Three European Countries. Agriculture, Ecosystems and Environment. 136: 35-39
9. Belzunces L.P., Suchail S. & Guez D., 2000. Characteristics of imidacloprid toxicity in two Apis mellifera subspecies. Environmental Toxicology and Chemistry. 19: 1901-5.
10. Beuhne R., 1910. Bee Mortality. J. Dept. Agric. Victoria. 8: 149-151
11. Biesmeijer J. C., Roberts S. P. M., Reemer M., Ohlemüller R., Edwards M., Peeters T., Schaffers A. P., Potts S. G., Kleukers R., Thomas C. D., Settele J. & Kunin W. E., 2006. Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands. Science. 313: 351-354.
12. Bonmatin J.M., Marchand P.A., Charvet R., Moineau I., Bengsch E.R. & Colin M.E., 2005. Quantification of imidacloprid uptake in maize crops. Journal of Agricultural and Food Chemistry. 53: 5336-41.
13. Bonmatin J.M., Moineau I., Charvet R., Fleche C., Colin M.E. & Bengsch E.R., 2003. A LC/APCI-MS/MS method for analysis of imidacloprid in soils, in plants, and in pollens. Analytical Chemistry. 75: 2027-33.
14. Bonmatin J.M., Moineau I., Charvet R., Colin M.E., Fleche C. & Bengsch E.R., 2005. Behaviour of Imidacloprid in Fields. Toxicity for Honey Bees. Environmental chemistry: green chemistry and pollutants in ecosystems. 483-94.
15. Bonmatin J.M. et al., 2007. Bees and systemic insecticides (imidacloprid, fipronil) in pollen: subnano-quantification by HPLC/MS/MS and GC/MS. Bee Life;
16. Brasse D. 2001. Overview about the poisoning incidents in honey bee populations and their clarification in Germany. Hazards of pesticides to bees; Avignon (France), September 07-09, 1999. Les Colloques INRA (Paris) 98: 141-147
17. Brittain C. A., Vighi M., Bommarco R. & Settele J., 2010. Impacts of a Pesticide on Pollinator Species Richness at Different Spatial Scales. Basic and Applied Ecology. 11: 106-115. Brittain C. A. & Potts S. G., 2011. The Potential Impacts of Insecticides on the Life-History Traits of Bees and the Consequences for Pollination. Basic and Applied Ecology. doi: 10.1016/j.baae.2010.12.004, 1-11.
18. Brodschneider R. & Crailsheim K., 2010. Nutrition and health in honey bees, Apidologie. 41, 278-294.
19. Bernal J. et al., 2010. Overview of Pesticide Residues in Stored Pollen and Their Potential Effect on Bee Colony (Apis mellifera) Losses in Spain. Journal of Economic Entomology. 103: 1964-71.
20. Brodschneider R. & Crailsheim K., 2010. Nutrition and health in honey bees. Apidologie. 41:278-294.
21. Brown M.J.F. & Paxton R.J., 2010. The conservation of bees: a global perspective. Apidologie. 40:410-416.
22. Carvell C., Pywell R. & Meek W., 2007.The conservation and enhancement of bumble bees in intensively farmed landscapes. Aspects of Applied Biology 81, 2007. Delivering Arable Biodiversity
23. De la Ruá P., Jaffé R., Dall Olio, Munoz I. & Serrano J., 2009. Biodiversity, conservation and current threats to European Honey bees, Apidologie 40: 263–284
24. de Groot A. P., 1953 Protein and amino acid requirements of the honey bee (Apis mellifica L.). Physiol. Comp. Oecol. 3: 197–285.
25. Dagnac T., Garcia-Chao M., Agruna M.J., Calvete G.F., Sakkas V. & Llompart M., 2010. Validation of an off line solid phase extraction liquid chromatography-tandem mass spectrometry method for the determination of systemic insecticide residues in honey and pollen samples collected in apiaries from NW Spain. Analytica Chimica Acta. 672: 107-13.
26. Ellis J. D., Evans J. D. & Pettis J., 2010. Colony Losses, Managed Colony Population Decline, and Colony Collapse Disorder in the United States. Journal of Apicultural Research. 49: 134-136.
27. Gallai N., Salles J., Settele J. & Vaissiere B., 2009. Economic valuation of the vulnerability of world agriculture confronted with pollination decline. Ecological Economics 68: 810-821.
28. Genersch E., Evans J. D. & Fries I., 2010. Honey Bee Disease Overview. Journal of Invertebrate Pathology. 103: 2-4.
29. Hatjina F. et al., 2010. Data on honey bee losses in Greece: a preliminary note. Journal of Apicultural Research. 49: 116-8.

30. Heintz C., Ribotto M., Ellis M. & Delaplane K., 2011. Best management practices for Beekeepers Pollinations Californias Agricultural Crops, Bee Culture. p.17-20
31. Herbst A., Rautmann D., Osteroth H.J., Wehmann H.J. & Ganzelmeier H., 2010. Drift of seed dressing chemicals during the sowing of maize. Aspects of Applied Biology. 99, 1-5.
32. Higes M. et al., 2009. Honey bee colony collapse due to Nosema ceranae in professional apiaries. Environmental Microbiology Reports. 1: 110-3.
33. Kamel A., 2010. Refined Methodology for the Determination of Neon icotinoid Pesticides and Their Metabolites in Honey Bees and Bee Products by Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS). Journal of Agricultural and Food Chemistry. 58: 5926-31.
34. Keppler J., Becker R., Spatz R. & Dechet F., 2010. Systemische insektizide Beizmittel – Auftreten und Relevanz von Guttation für die Entwicklung von Honigbienenkolonien. - Julius-Kühn-Archiv, 428: 133
35. Richards A. J., 2001. Does low biodiversity resulting from modern agricultural practice affect crop pollination and yield? Ann. Bot. 88: 165–172. (doi:10.1006/anbo.2001. 1463)
36. Kleijn D., Kohler F., Baldi A., Batary P., Concepcion E. D., Clough Y., Diaz M., Gabriel D., Holzschuh A., Knop E., Kovacs A., Marshall E. J. P., Tscharntke T. & Verhulst J., 2009. On the Relationship Between Farmland Biodiversity and Land-Use Intensity in Europe. Proc. R. Soc. B 276: 903-909.
37. Klein A.M., 2011. Plant-Pollinator Interactions in Changing Environments. Basic and Applied Ecology doi:10.1016/j.baae.2011.04.006, 1-3.
38. Klein A.M., Vaissiere B.E., Cane J.H., Steffan-Dewenter I., Cunningham S.A., Kremen C. & Tscharntke T., 2007. Importance of pollinators in changing landscapes for world crops. Proc. R. Society. B. 274: 303-313.
39. Le Conte Y., Ellis M. & Ritter W., 2010. Varroa mites and honey bee health: can Varroa explain part of the colony losses? Apidologie. INRA/DIB-AGIB/EDP Sciences, 2010. DOI: 10.1051/apido/2010017
40. Madrigal A., 2010. Bee colony losses may have several causes. Wired Science.http://www.wired.com/wiredscience/2010/01/colony-collapse-lives/
41. Mao W., Schuler M. A. & Berenbaum Mr., 2011. CYP9Q-mediated detoxification of acaricides in the honey bee (Apis mellifera) PNAS DOI 10.1073/pnas.1109535108
42. Moritz R. F. A., de Miranda J., Fries I., Le Conte Y., Neumann P. & Paxton R. J., 2010. Research Strategies to Improve Honey bee Health in Europe. Apidologie. 41: 227-242.
43. Morrica P., Fidente P., Seccia S. & Vanni F., 2005. Analysis of nicotinoid insecticides residues in honey by solid matrix partition clean-up and liquid chromatography-electrospray mass spectrometry. Journal of Chromatography A. 1094: 175-8.
44. Müller A., Krebs A. & Amiet F., 1997. Bienen: Beobachtung, Lebensweise. – Naturbuch-Verlag, München: pp.384
45. Nauen R., Ebbinghaus-Kintscher U. & Elbert Aea., 2001. Acetylcholine receptors as sites for developing neonicotinoid insecticides. Biochemical sites important in insecticide action and resistance. 77-105.
46. Neumann P. & Carreck N., 2010 Honey bee colony losses. Journal of Apicultural Research 49(1): 1-6 DOI 10.3896/IBRA.1.49.1.01
47. Nikolakis A., Chapple A., Friessleben R., Neumann P., Schad T., Schmuck R., Schnier H., Schnorbach H., Schöning R. & Maus C., 2009. An effective risk management approach to prevent bee damage due to the emission of abraded seed treatment particles during sowing of seeds treated with bee toxic insecticides. Julius-Kühn-Archiv. 423: 132-148
48. Nguyen B.K. et al., 2009. Does Imidacloprid Seed-Treated Maize Have an Impact on Honey Bee Mortality? Journal of Economic Entomology. 102: 616-23.
49. Pederson K. & Omholt S.W., 1993. A comparison of diets for honey bee. Norwegian Journal of Agricultural Science. 7:213-219.
50. Pettis J.S. & Delaplane K. S., 2010. Coordinated responses to honey bee decline in the USA.. Apidologie. 41 (3): 256-263
51. Pham-Delegue M.H., Decourtye A. & Lacassie E., 2003. Learning performances of honey bees (Apis mellifera L) are differentially affected by imidacloprid according to the season. Pest Management Science. 59: 269-78.
52. Piotr Semkiv & Piotr Skubida. 2010. Evaluation of the Economical aspects of Polish beekeeping. Journal of Apicultural Science. 54 (2).
53. Potts S. G., Biesmeijer J. C., Kremen C., Neumann P., Schweiger O. & Kunin W. E., 2010. Global Pollinator Declines: Trends, Impacts and Drivers. Trends in Ecology and Evolution. 30: 1-9.
54. Potts S. G., Roberts S. P. M., Dean R., Marris G., Brown M. A., Jones R., Neumann P. & Settele J., 2010. Declines of Managed Honey Bees and Beekeepers in Europe. Journal of Apicultural Research 49: 15-22.
55. Richards A. J., 2001. Does low biodiversity resulting from modern agricultural practice affect crop pollination and yield? Ann. Bot. 88, 165–172. (doi:10.1006/anbo.2001. 1463)
56. Roe R.M., Iwasa T., Motoyama N. & Ambrose J.T., 2004. Mechanism for the differential toxicity of neonicotinoid insecticides in the honey bee, Apis mellifera. Crop Protection. 23: 371-8.
57. Rortais A., Arnold G., Halm M.P. & Touffet-Briens F., 2005. Modes of honey bees exposure to systemic insecticides: estimated amounts of contaminated pollen and nectar consumed by different categories of bees. Apidologie. 36: 71-83
58. Rosenkranz P., 2005. Varroa Control Concept in Conjunction with the Population Dynamics of Bee Colonies. – In: Forster, R.,

E. Bode & D. Brasse (eds.): Das „Bienensterben" im Winter 2002/2003 in Deutschland – Zum Stand der wissenschaftlichen Erkenntnisse. Bundesamt für Verbraucherschutz und Lebensmittelsicherheit (BVL) Dienststelle Braunschweig: 53-59

59. Rosenkranz P., Aumeier P. & Ziegelmann B., 2010. Biology and Control of Varroa Destructor. Journal of Invertebrate Pathology. 103: 96-119
60. Ruzhong G. & Rui C., 1999. Evaluation on toxicity and safety of imidacloprid to environmental organisms. Pest Sci Administration
61. Schmuck R., Schoning R., Stork A. & Schramel O., 2001. Risk posed to honey bees (Apis mellifera L. Hymenoptera) by an imidacloprid seed dressing of sunflowers. Pest Management Science. 57: 225-38.
62. Schoning R. & Schmuck R., 2003. Analytical determination of imidacloprid and relevant metabolite residues by LC MS/MS. Bulletin of Insectology. 56: 41-50.
63. Schroeder A., 2011. Milben und Verluste. Deutsches Bienen-Journal 9/2011: 16
64. Stark J.D., Jepson P.C. & Mayer D.F., 1995. Limitations to Use of Topical Toxicity Data for Predictions of Pesticide Side-Effects in the Field. Journal of Economic Entomology. 88: 1081-8.
65. Suchail S., Guez D. & Belzunces L.P., 2001. Discrepancy between acute and chronic toxicity induced by imidacloprid and its metabolites in Apis mellifera. Environ Toxicol Chem. 20: 2482-6.
66. Tasei J. N.& Aupinel P., 2008. Nutritive value of 15 single pollens and pollen mixes tested on larvae produced by bumble bee workers (Bombus terrestris, Hymenoptera: Apidae). Apidologie. 39: 397–409.
67. Titera D., Bednář M., Dolínek J., Haklová M., Jaša T., Kamler F. & Veselý V., Hygiene in the apiary (A manual for hygienic beekeeping). BeeShop
68. Thompson H.M. & Thorbahn D., Review of honeybee pesticide poisoning incidents in Europe - evaluation of the hazard quotient approach for risk assessment. Hazards of pesticides to bees - 10th International Symposium of the ICP-Bee Protection Group, 2009
69. vanEngelsdorp D. & Meixner M., 2010. A historical review of managed honey bee populations in Europe and the United States and the factors that may affect them. Journal of Invertebrate Pathology. 103: 80–95
70. Vural H. & Karaman S., 2009., Socio-Economic Analysis of Beekeeping and the Effects of Beehive Types on Honey Production. NotulaeBotanicaeHortiAgrobotanici Cluj-Napoca. 37(2): 223-22
71. Wahl O. & Ulm K., 1983. Influence of pollen feeding and physiological condition on pesticide sensitivity of the honey bee Apis mellifera carnica. Oecologia 59, 106-128.
72. Widart J. et al., 2007. Development and validation of a multi-residue method for pesticide determination in honey using on-column liquid-liquid extraction and liquid chromatography-tandem mass spectrometry. Journal of Chromatography A. 1152: 116-23.
73. Wilkins S., Brown M. A. & Cuthbertson A., 2007. GS. Perspective The Incidence of Honey Bee Pests and Diseases in England and Wales. Pest Management Science. 63: 1062-1068
74. Winfree R., Aguilar R., Vazquez D. P., LeBuhn G. & Aizen M. A., 2009. A Meta-Analysis of Bees' Responses to Anthropogenic Disturbance. Ecology. 90: 2068-2076. EC, 2003. Directive 2003/82/EC of the Commission amending Council Directive 91/414/EEC as regards standard phrases for special risks and safety precautions for plant-protection products, Official Journal of the European Union. L 228/1: 19.09.2003.
75. European Commission, (2004), REPORT on the implementation of Council Regulation (EC) No 1221/97 laying down general rules for the application of measures to improve the production and marketing of honey, COM(2004) 30 final
76. AFSSA, 2009.Weakening, collapse and mortality of bee colonies. 2009. AFSSA (French Food Safety Agency)
77. APENET, 2009-2010. English reports 2009 and 2010 of the national project (http://www.reterurale.it/apenet)
78. Bee Mortality and Bee Surveillance in Europe-SCIENTIFIC REPORT submitted to EFSA- CFP/EFSA/AMU/2008/02. December 2009.http://www.efsa.europa.eu/en/scdocs/doc/27e.pdf
79. Bundesamt für Landwirtschaft (2009): Bienen Monitoring in der Schweiz. Eidgenössisches Volkswirtschaftsdepartement: Bundesamt für Landwirtschaft BLW - Fachbereich Pflanzenschutzmittel. Internet address: http://www.blw.admin.ch/themen/00011/00075/01127/index.html?lang=de&download=NHzLpZeg7t,lnp6I0NTU042l2Z6ln1acy4Zn4Z2qZpnO2Yuq2Z6gpJCEdH54fmym162epYbg2c_JjKbNoKSn6A
80. ELO/ECPA/RifCon/E-Sycon (2011). Pollinators and Agriculture. Published joint report.
81. Fleming, G. (1871): Animal Plagues: Their History, Nature, and Prevention. Chapman & Hall, London
82. JORF, 2003. Arrêté du 28 novembre 2003 relatif aux conditions d'utilisation des insecticides et acaricides à usage agricole en vue de protéger les abeilles et autres insectes pollinisateurs, JORF n°76 du 30 mars 2004 page 6099.
83. Multifunctional landscapes: Why good field margin management is important and how it can be achieved. OPERA Research Center. http://www.opera-indicators.eu/assets/files/Documents/Multifunctional%20landscapes1.pdf
84. Operation Pollinator. www.operationpollinator.com
85. http://www.eln-fab.eu/uploads/Functional%20AgroBiodiversity,%20for%20a%20more%20sustainable%20agriculture%20and%20countryside%20in%20Europe(1).pdf
86. Special Issue: Colony Losses (2010). Journal of Apicultural Research. Volume 49, No. 1, pp 1-138 (includes 31 refereed publications).
87. The UNEP Report: Global Honey Bee Colony Disorders and Other Threats to Insect Pollinators http://www.unep.org/dewa/Portals/67/pdf/Global_Bee_Colony_Disorder_and_Threats_insect_pollinators.pdf

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