Bee health in Europe

An Overview*

UNIVERSITÀ CATTOLICA del Sacro Cuore

OPERA Research Center

Bridging science and policy

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

It is an independent, non-profit scientific organisation, committed to supporting the successful implementation of agri-environmental measures into European legislation.

The fundamental contribution of OPERA is to use the potential of existing scientific research, expertise and knowledge to support stakeholders in political and technical decisions concerning agriculture, 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 the efficient implementation of agriculture-related policies in the EU.

OPERA would like to thank all members of the OPERA Bee health working group for the substantive inputs, constructive attitude and valuable suggestions made towards the development of the report and the technical contributors who shared their evaluations, analysis, insights and valuable expertise with the group.

* This document is a synopsis of the original OPERA Research Centre "Bee Health in Europe - Facts & Figures" released in 2011. The full report can be consulted and downloaded from the OPERA website: www.operaresearch.eu

Completed December 2012

FOREWORD

Widespread interest in the health of bees is nothing new. This concern has stimulated scientists to produce new data and evaluations to decipher the mechanisms that influence bee health. Studies, hive surveillance and the stringent monitoring of pesticide use have generated a significant amount of information on bee health: our knowledge of the subject is expanding accordingly. This new data is essential, but also makes it increasingly difficult to grasp a holistic and comprehensive view of the issue. This is what has motivated OPERA to produce a report.

Our "Bee health in Europe – Facts & Figures" compendium gave the most up-to-date information on the topic when it was published in August, 2011. Now, just more than a year later, we're in a position to start sharing compelling new information that is helping to deepen and refine our understanding of threats to bee health and giving us insight into measures we can take to improve it.

In this overview, we highlight the still-valid main points of the earlier document while at the same time giving in this foreword a preview of new data that we will present in detail in our next full review, scheduled for publication in 2013.

In the next report, we will address scientific studies like the one carried out by the University of Sheffield in the UK. Published in Science earlier this year, the research found that infection with the *Varroa* destructor mite caused an increase in Deformed Wing Virus (DWV) frequency among honey bee colonies to 100% from just 10%. This spread of DWV, which can seriously harm honey bee health and productivity, was accompanied by a million-fold increase in the number of virus particles infecting each honey bee and led to the emergence of a single virulent strain of the disease.. The spread of *Varroa* has then caused DWV to emerge, leading the authors to conclude that the association may be responsible for the death of millions of colonies around the world.

We will also refer to evaluations such as that published recently by EFSA on the interaction between pesticides and other factors in terms of their effects on bees, with a focus on three major issues: importance of the different exposure routes; multiple exposure to pesticides and interactions between diseases and susceptibility of bees to pesticides.

We will, of course, also include the latest information available on developments in the regulatory framework in pesticides and veterinary medicines as well as colony losses in Europe or measures meant to protect bee health in other parts of the world.

This sustained research focus and the publication of emerging data in renowned journals testifies to the seriousness with which the scientific community is taking the issue of bee health. We applaud the continuing efforts of our colleagues and look forward to sharing the newest results in future reviews.

Prof. Ettore Capri
Director, OPERA Research Centre

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The bee is one of the most economically important insects, producing honey and pollinating crops that account for about 35% of global food production. With insect pollination valued at about €20 billion each year in Europe-nearly 15 times the €140 million generated by the region's annual honey sales- this is clearly the bee's most significant contribution to agriculture.

Any decline in bee populations can lead to reduced pollination and this may, in turn, have economic and ecological consequences. It could reduce the diversity of wild plants and disturb the stability of the wider ecosystem, crop production, food security and human welfare. We've seen clear evidence of a link between recent declines in pollinators and the plants that rely on them.

At the same time, the media often uses news of honey bee colony losses to describe declines in general. Reasons for the deaths are not always well investigated and information can be misleading: taken by itself, this data suggests that the honey bee is close to extinction, which is clearly not the case. A decline in the number of hives, for example, may sometimes be simply explained by the fact that there are fewer beekeepers.

This report aims then to describe bee population trends in Europe, to determine what might explain them, and recommend steps we can take to improve the situation.

WHAT THE DATA SHOW

With more than 1,000 known bee species in Europe, the first step towards gathering meaningful data is narrowing the focus to a representative group. The managed honeybee Apis mellifera and its wild equivalents, solitary bees and bumble bees, seem to fit this profile best.

Though patterns are mixed, the data for 2006 and 2007 published by EFSA in 2008 show winter losses ranging from 7% to 50% in various European countries. Winter deaths have tended to increase in the last decade, though they are not necessarily different from those reported in single years in the past. And despite losses, colony collapse as described in the USA has not been systematically reported in Europe.

THREATS TO BEE HEALTH

People have developed many theories to explain the decline in honey bees, but scientists have narrowed the list of likely possibilities to elements including disease, environmental factors, and pesticides. Economics and beekeeping practices can also have significant effects.

Most researchers agree too that losses are probably not caused by any single factor, but rather by a combination of interrelated pressures. Nonetheless, there is a culprit that turns up repeatedly: *Varroa* destructor, a parasitic mite.

PARASITIC MITES AND DISEASES

Research shows that the main cause of honey bee colony losses is *Varroa*, a parasite found in almost every apiary in Europe. The "Deutsche Bienenmonitoring" project showed that honey bee losses are correlated with *Varroa* infection, a conclusion similar to that described in the Journal of Apicultural Research's special issue "Colony Losses". While the issue's authors have a variety of opinions, most pinpoint *Varroa* and other diseases as key factors. High overwinter colony losses in Europe generally involve damage caused by the mite.

BEEKEEPING PRACTICES

Keeping honey bee colonies requires some basic knowledge; successful beekeeping requires considerably more. Beekeepers need to understand the biology and behaviour of bees and the changing needs of colonies throughout the year. This understanding is essential to enabling vital growth conditions, to keeping bees healthy during the whole year, and to maintaining strong, healthy colonies with enough food to live through the winter. In the spring, only healthy colonies with a certain strength and a minimum number of bees will develop into colonies that produce a good honey yield later in the season.

HABITAT LOSS

Researchers have also identified environmental issues such as habitat loss, reduced biodiversity and insufficient amounts of high quality nectar and pollen as major factors affecting bee health. Changes in land use and crop management as well as the traditional farming and forestry practices that provided rich habitats lead to a lack of biodiversity. Bee foraging is also compromised by society's efforts to "neaten" landscapes by removing wild flowers and weeds from lawns, parks, and farms.

PESTICIDE INCIDENTS LINKED TO MISUSE

Pesticide use is often assumed to damage bee health. And while single poisoning events linked to spray application have been reported in many countries, they do not seem to cause widespread colony losses. When pesticide-linked incidents do happen, it's usually because of product misuse or due to farmer ignorance of product labels combined with poor communication with beekeepers. Sometimes it's a disregard for good beekeeping practices itself.

Incident reports show that pesticide-related poisonings are generally declining in monitored countries. This probably reflects the fact that regulatory systems guiding plant protection product (PPP) approval and honey bee risk assessment generally work, and that safe handling has become more common.

EUROPEAN BEEKEEPING IS LARGELY UNPROFITABLE

Evidence also suggests that a drop in managed honey bee colonies in Europe may simply be linked to a decline in beekeeping. Though the number of beekeeper-managed colonies rose between 1965 and 2005 in Southern Europe, especially in Greece, Italy and Portugal, the overall trend has been a decline, with numbers in Central and Western Europe falling since 1965.

While there's little information on the economics of beekeeping in Europe, the activity is widely considered unprofitable when carried out on a small scale as a hobby or secondary activity. Data suggest a strong correlation between the number of beehives and the prices of honey and other apicultural products.

RECOMMENDATIONS FOR IMPROVING BEE HEALTH

The considerations above have led us to several recommendations. We urgently need more efficient treatments for bee pests and we need to monitor resistance to existing treatments. We need to train beekeepers, developing guidelines for beekeeping practices, especially for hygiene procedures and for hobby beekeepers. We also need to support beekeepers economically to compensate the high costs of combating pests.

In terms of the environment, we need to focus on habitat conservation that benefits pollinator species. We need policies that encourage farmers to develop and manage habitats that will meet the nutritional needs of healthy bees. We should also encourage migratory beekeeping, which improves access to increased quantities of high-quality pollen and nectar, though we also need accompanying measures to prevent the spread of pests and diseases .

We need better communication among and within EU member states on good agricultural and beekeeping practices. Knowledge and technical improvements should be shared and implemented quickly. We also need to encourage better communication between agricultural actors, scientists and regulators.

Finally, we need to continue and strengthen research activities and to harmonise Europe-wide monitoring systems. Research should be broadened to focus on bee pests and diseases, the interaction of pesticides with other parameters and on wild bees. Europe needs standardised, improved surveillance systems that are also equipped to monitor wild bees.

CHAPTER 1. THE SITUATION IN THE EU

Context

The bee is one of the most economically important insects, producing honey and pollinating crops that account for about 35% of global food production.[1] With insect pollination valued at about €20 billion each year in Europe[2] -nearly 15 times the €140 million generated by the region's annual honey sales[3] -this is clearly the bee's most significant contribution to agriculture.

Any decline in bee populations can lead to reduced pollination and this may, in turn, have economic and ecological consequences. It could reduce the diversity of wild plants and disturb the stability of the wider ecosystem, crop production, food security and human welfare. We've seen clear evidence of a link between recent declines in pollinators and the plants that rely on them.[4]

At the same time, the media often uses news of honey bee colony losses to describe declines in general. Reasons for the deaths are not always well investigated and information can be misleading: taken alone, the data suggests that the honey bee is close to extinction, which is clearly not the case. A decline in the number of hives, for example, may sometimes simply be explained by the fact that fewer beekeepers are pursuing the hobby. This report aims then to describe bee population trends in Europe, to determine what might explain them, and recommend steps we can take to improve bee health.

What the Data Show

With more than 1,000 known bee species in Europe,[5] it's critical to focus on a representative group. The managed honeybee *Apis mellifera* and its wild equivalents, solitary bees and bumble bees seem to do this best: *A. mellifera* is the only managed honey bee species in Europe and is the most economically valuable pollinator of crop monocultures worldwide:[6] farmers often need managed honey bee hives to pollinate their crops when wild bees do not visit the fields.

Gathering data on bee mortality is still difficult though. The exact number of managed colonies is hard to determine because data collection methods vary between countries.[7] What's more, the numbers probably don't represent all colonies: not all beekeepers are organised into confederations and those that are do not always give correct numbers because insurance, for instance, is calculated per hive.

Data on wild bees are based on research projects that are usually limited to a few species, and on field observations related to declines in crop yields.[8] Drawing conclusions about population trends is difficult because not all wild bee species have been monitored over time.

Despite these difficulties, it's essential to make a first attempt. The data discussed below have been collected from a variety of sources including: 1. monitoring and surveillance systems such as the "Deutsche Bienenmonitoring" (German Bee Monitoring) project, which looks at more than 1,200 bee colonies from about 120 apiaries all over Germany; 2. disease-related incident recording systems such as the UK's National Bee Unit (NBU), which runs an integrated programme involving laboratory diagnostics, programme support, research personnel and bee inspectors to monitor colonies for pests and diseases in England and Wales; 3. pesticide incident reporting from systems in eight European countries (Denmark, Finland, France, Germany, Italy, Netherlands, Switzerland and the UK) and, finally, from research projects.

1 Klein et al., 2007
2 Gallai et al., 2009
3 Moritz et al., 2010
4 Potts et al., 2010; Moritz et al., 2007; De la Rua et al., 2010
5 Müller et al., 1997
6 Klein et al., 2007
7 Potts et al., 2010
8 Aubertot et al., 2005

If collecting the data is the initial challenge, figuring out how to interpret is the next. Many countries have reported declines in managed honey bee colonies and some wild bee species, but others have seen some increases. There are declines in managed colony numbers in Central Europe, but increases in Mediterranean countries. Despite these trends, it is difficult to identify a clear pattern: [9] the number of hives increased between 2006 and 2007 in Italy, Germany, Latvia and Slovakia, for instance, but declined in France, Romania and the Czech Republic.

Overall, the statistics indicate losses. Expressed as deaths and measured most often over the winter, they range from 7% to 50% (Table 1). Winter deaths have tended to increase in the last decade, though the figures are sometimes very similar to those reported in single years in the past (see e.g., for Germany, Rosenkranz 2005, and Schroeder, 2011).

Table 1. European statistics concerning the number of hives, beekeepers and mortality rate of hives, beekeepers and mortality rate of bee colonies for 2006 and 2007, from 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

* 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).

9 Potts et al., 2010

Records published by a French research institution in 2011 showed that losses in the country have been constant since 2008 and range from 23.3% to 29.2% over the winter.[10] The cause is often given as natural death after being weakened by winter. We haven't seen a trend for an increase over the past years.

It's difficult to comment on trends in wild species because of the lack of data. Still, Biesmeijer et al. (2006) demonstrated that the diversity of wild bees has fallen significantly in most landscapes in both the UK and in the Netherlands. Mobile, generalist bee species tended to prosper, while those that focus on a specific diet or habitat and stay put tended to decline. The researchers also saw parallel losses of species diversity in wild plants.

It is important to note that despite observed colony losses, a phenomenon–characterised by the sudden collapse of a colony that has a significant amount of larva and stores but a lack of healthy adult bees in the hive and seen in the US–has not been detected in Europe.[11]

CHAPTER 2. THREATS TO BEE HEALTH

While historical reports show that extensive honey bee losses are not unusual,[12] we're now able to take a more scientific approach to finding possible explanations: multi-factorial studies, surveillance systems monitoring bee health in the field and stringent monitoring of pesticide use has generated more data than we've ever had before.

And while people have developed many theories to explain bee deaths, scientists have generally narrowed the list of real possibilities to elements including disease, environmental factors, and pesticides. Economics and beekeeping practices can also have significant effects.

Most researchers agree too that losses are probably not caused by any single factor, but rather by a combination of interrelated pressures. Nonetheless, there is a culprit that turns up repeatedly: *Varroa destructor*, a parasitic mite.

Parasitic Mites and Diseases

Research shows that *Varroa*, a parasite that can be found in almost every apiary in Europe, is likely the main cause of honey bee colony losses.[13]

The "Deutsche Bienenmonitoring" project found that losses can be correlated with infection,[14] a conclusion in keeping with the overall findings given in the Journal of Apicultural Research's special issue "Colony Losses". While the focus and conclusions of the issue's individual publications are diverse, most contributors identify *Varroa* and other diseases as key to bee demise. High colony losses during the European winter generally involve damage caused by the mite.

Varroa is an external parasite that attaches to the body of the *Apis* species and breeds within the colony by laying its eggs in the cocoons of bee larvae and feeding on them. Depending on the climate, the resulting damage can appear during the winter, leading to general weakening and often complete loss of the colony.

A high level of *Varroa* infestation can cause colony loss by itself, but the mite is also a known vector of disease. Bee viruses don't usually cause any obvious signs of illness, but they can dramatically affect health and shorten lives.

Only a small number of approved Varroacides are commercially available for beekeepers. 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.

Many treatments are linked to complications that result in inefficient parasite control. Certain treatments, for instance, can only be used successfully if there are no eggs, larvae or pupae during the winter: this is not always the case. Other

10 Institut technique et scientifique de l'apiculture et de la pollinisation
11 Genersch et al., 2010; EFSA, 2009
12 Fleming, 1871; Beuhne, 1910; Rosenkranz, 2005; Afssa, 2009; van Engelsdorp and Meixner, 2009
13 Genersch et al., 2010, Afssa, 2009 for a review
14 Genersch et al., 2010

legally available treatments, that is, those that have been evaluated and authorised for use, are frequently not effective enough to reduce *Varroa* pressure.

Low efficiency treatments may mean that surviving colonies are threatened again if too many mites remain. There is also a good chance of an unexpected build-up of the mite population which, even if detected, may be noticed too late to treat.

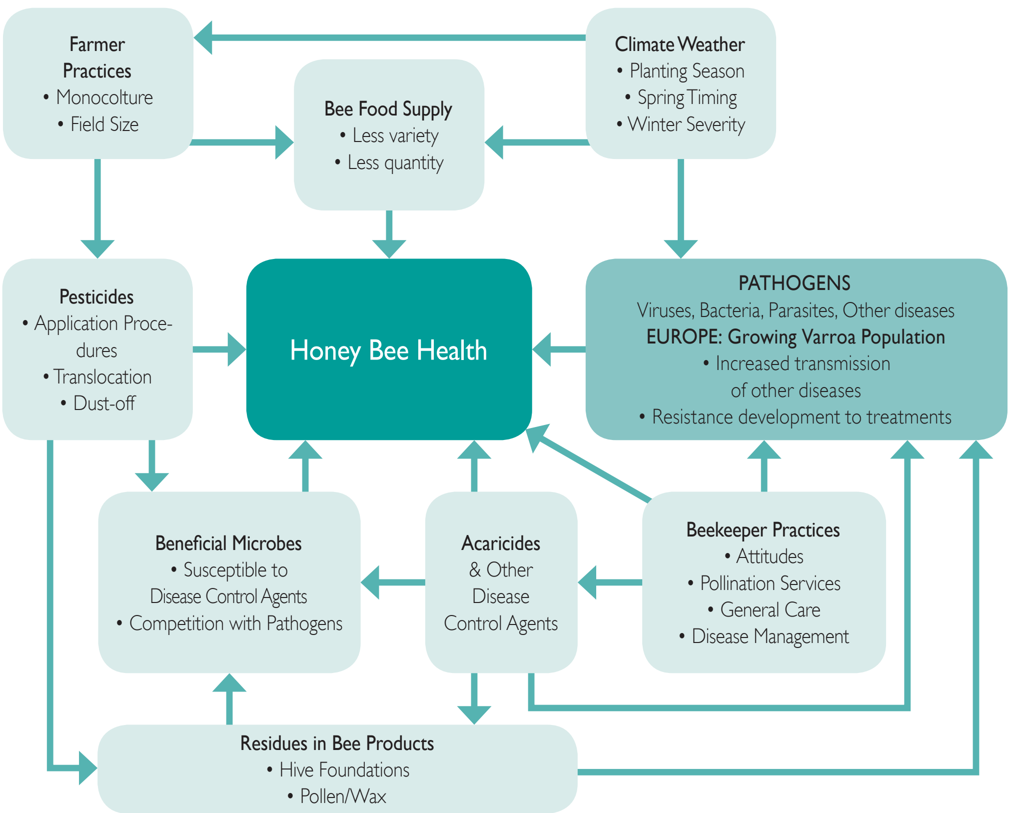
There is therefore an urgent need for more efficient, legally available, affordable treatments against *Varroa*, which the European Commission acknowledges as the main threat to honey bees. As the market for such minor-use products is rather small, only a few companies invest in the registration procedures. These procedures should then be simplified and accelerated for new or improved methods developed by scientists.

Six of the 18 or so viruses that infect honey bees (DWV, Black queen cell virus, Sacbrood virus, Kashmir bee virus, Acute bee paralysis virus, and Chronic bee paralysis virus (CBPV)) are most commonly recorded around the world. CBPV is very widespread in Britain and can cause mortality in bee colonies, particularly during periods when bees are confined to their hives because of, for instance, bad weather.

Other diseases such as *Nosema* and bacterial infections like European and American foulbrood, tracheal mites and fungal diseases can also affect colonies. Two species of the microsporidian fungal *Nosema* parasite, *N. apis* and *N. ceranae*, are widespread and can be particularly harmful during the winter. Some, like other *Nosema* species, virus infections or foulbrood, can damage colonies during the spring and summer.

Despite *Varroa's* key role, most researchers agree that bee deaths are not caused by the mite alone. Other contributing factors, many of which may reduce the mite's resistance to disease, are shown in the figure below.

Figure 1. Interrelationship of bee health stressors (Adapted from Le Conte et al., 2010)



One critical factor is the beekeeper's ability to control bee diseases. Colonies that are incorrectly treated against *Varroa,* for example, are not likely to survive the winter in most regions of Europe.

Beekeeping practices

It is clear then that while keeping honey bee colonies requires some basic knowledge, successful beekeeping requires considerably more. Beekeepers need to understand the biology and behaviour of bees and the changing needs of colonies throughout the year. This understanding is essential to enabling vital growth conditions, to keeping bees healthy during the whole year, and to maintaining strong, healthy colonies with enough food to live through the winter. In the spring, only healthy colonies with certain vitality and a minimum number of bees will develop into colonies that produce a good honey yield later in the season.

Controlling disease is the most essential factor for successful beekeeping over the years. It is therefore critically important that beekeepers are both well informed about the identification and biology of diseases and also aware of the strengths and limitations of different treatment methods. Special attention is needed in areas where honey is produced later in the season and where more colonies from migratory beekeepers are concentrated as diseases can spread very easily in these environments.

Keeping colonies healthy and vital means frequent colony rejuvenation: beekeepers need to be well informed about procedures for creating nuclei and rejuvenating queens.

Colony placement should take the microclimate into account because unfavourable locations may result in lower honey yields and in adverse effects on bee health. It may sometimes be useful or even necessary to supply a water source for the bees. The beekeeper also needs to ensure that colonies have enough food resources and, if necessary, to supplement this (sugar syrup, protein patties, etc.) to maintain vitality and avoid starvation though the whole year, but especially during the winter.

Hive hygiene needs special attention. To maintain bee health, old combs should be removed and replaced with new combs with fresh wax frequently. Good beekeeping also requires knowledge of honey production, storage, food safety issues and hygienic requirements.

Recommendations for implementing quality training in European Member States (MS) have been put forward by the European Commission and the European Council and 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 to the development and implementation of good beekeeping guidelines from the policy side.

Habitat Loss

Researchers have also identified environmental issues such as habitat loss, reduced biodiversity and insufficient amounts of high quality nectar and pollen as major contributing factors to bee health.

Foraging bees need a variety of natural nectar and pollen sources to prevent nutritional deficiency and to strengthen the immune system.[15] Bees that feed on pollen from a variety of plants are healthier than those that eat only one type[16] and areas of high biodiversity are more likely to provide sufficient nutrition through the year. Pollen quality is also important in determining bee sensitivity 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 substitute during development.[17]

The increased numbers of large farms growing one type of crop have resulted in reduced variety, quality, and quantity of pollen. Changes in land-use, agricultural crop management, land abandonment as well as the loss of traditional farming and forestry practices, which previously generated rich habitats, are some of the major causes for biodiversity

15 Brodschneider and Crailsheim, 2010; Alaux et al., 2010; Pederson and Omholt, 1993
16 Tasei and Aupinel, 2008
17 Wahl and Ulm, 1983

loss. Bee foraging and nesting is also compromised by society's efforts to "neaten" landscapes by eliminating wild flowers and weeds in places such as lawns, parks, and farm boundaries.

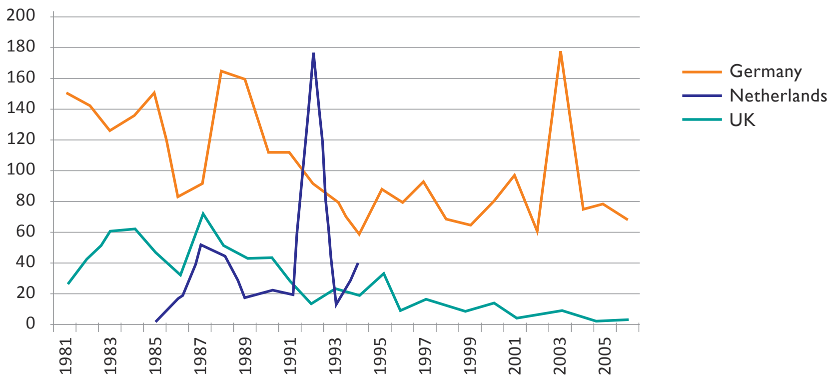
Habitat loss and fragmentation is one of the biggest factors impacting bee declines (Brown and Paxton, 2010) and is especially important for wild bees, which are particularly dependent on special habitats and wild plants.

A review looking at falling numbers of pollinators in agricultural areas found that habitat destruction through removal of hedges, development of monoculture, irrigation practices, etc., was the major cause of such declines.[18]

Pesticide Incidents Often Linked to Misuse

Pesticides are often assumed to damage bee health. Nonetheless, while single poisonings linked to spray applications have been reported in many countries, pesticides don't appear to be a main cause of widespread colony losses.

Figure 2. Pesticide incidents in the UK, the Netherlands and Germany, 1981-2006 (Source: 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

When pesticide-related incidents do happen, they are most often due to the misuse of products[19] and/or to farmer ignorance of product label statements, combined with poor communication with beekeepers or even disregard for good beekeeping practices.

Most pesticide-related bee poisoning is linked to exposure to direct overspray in a treated crop or to a product's drift into adjacent flowering areas. This is usually because of the inappropriate use of a product classified as hazardous for bees, which eat the contaminated pollen and nectar.

Using pneumatic drillers with air pressure applications may also spread dust from treated seeds, contaminating flowering crops nearby. A limited number of hive poisonings were reported in France and Spain before 2008. Recent incidents were reported in Germany after sowing of maize in 2008[20] and in Slovenia.

Researchers have also discussed and highlighted the exposure of bees via drops of plant sap that contain residues of insecticides such as neonicotinoids. Recent research data[21] show that this so-called guttation is relatively unimportant

18 Aubertot et al., 2005
19 AFSSA, 2009; WIIS, etc.
20 Pistorius et al., 2009, Forster, 2009; Nikolakis et al., 2009), Austria (Girsch and Moosbeckhofer, 2011)
21 Pistorius et al., unpublished; Keppler et al., 2010

compared to spray application poisoning. The data show that only small numbers of bees in a hive may be poisoned under certain circumstances, even if colonies are directly next to crops. The risk is likely to decrease rapidly as colonies move even meters away from treated areas and beekeepers can easily avoid problems by providing clean water.

Sub-lethal amounts of pesticides are often detected in monitored colonies and some think this residue may damage bee health over the long term. Study results haven't found a correlation between these residues and colony mortality though.[22] Most relevant studies also show that the compounds found most frequently and/or at highest concentrations include acaricidal substances intentionally introduced into the hives to control *Varroa*.[23]

The Rigorous Approval Route for Plant Protection Products

Reports show that pesticide-related bee incidents are generally declining in monitored countries. This probably means that regulatory systems governing bee risk assessment work and that more farmers are handling products safely.[24]

Plant protection products (PPP) undergo a thorough approval process that is meant to protect humans and the environment. Once on the market, incident reporting, investigation systems and post-approval monitoring go a long way towards protecting honey bees.

In Europe, the only species that get dedicated risk assessments are humans and honey bees. We therefore have more detailed knowledge of pesticides' possible impact on bees than for other pollinating species. EU regulations[25] require risk assessments for all pesticides that honey bees may be exposed to.[26]

This is nothing new–pollinators have been identified as organisms needing protection from pesticide side-effects from the earliest days of regulatory testing. Since then, European bodies such as the Organisation for Economic Co-operation and Development (OECD) and the European and Mediterranean Plant Protection Organisation (EPPO) have published many guidelines to ensure standardised testing methods.

Since the 1980s, PPP risks to honey bees have been assessed using standardised schemes relying on initial toxicity studies in the lab that are followed by semi-field studies if needed and then possibly by field studies. Because of increased exposure potential, sprayed PPPs are evaluated separately from pesticides that can be applied as seed treatments, soil drenches, granules or as pre-blossom sprays.

The scheme for sprayed products has been in place for nearly 20 years, though that for other pesticides has been formally developed recently.[27] Pesticide registration relies on a strict set of rules meant to ensure that protection goals are met. Regulators may also recommend product-specific risk-management measures that appear on the labelling.

Post-Approval Monitoring

PPP evaluation doesn't stop with approval. Once on the market, products are followed so that exposure to bees is limited. Most such activities focus on neonicotinoid seed treatment products.

Incident reporting allows beekeepers to register events that may be linked to pesticides. In the UK and Germany, beekeepers can send the authorities samples for further investigations, which involve plant protection services and veterinarians, free of charge. The authorities also carry out biological analyses, inspection for bee diseases and, if appropriate, chemical analyses of the samples. France has a similar system. A broader alert system that would inform all countries about accidents or misuse is being developed by the OECD.

22 Genersch et al., 2010; Chauzat et al., 2009
23 Chauzat et al., 2006; 2009; Genersch et al., 2010; Mullin et al., 2010; Johnson et al., 2010
24 Thompson and Thorbahn, 2009
25 Regulation 1107/2009
26 The risk assessment that has been developed for "bees" basically relies on tests performed on the honey bee. This is partially due to their role in pollination, but also to their close relationship with man. Guidelines have focused on this species because of practical reasons related to "ease of rearing" (or "amenability as a test species"), and because of its role as an indicator species: EPPO, 2001; 2003; 2010. Although not specifically directed at pollinators, tests of effects of PPPs on other "non-target" arthropods such as predatory mites, parasitic wasps, lacewings and ladybirds are also carried out. These risk assessments are intended to cover non-Apis pollinators as well.
27 EPPO, 2010

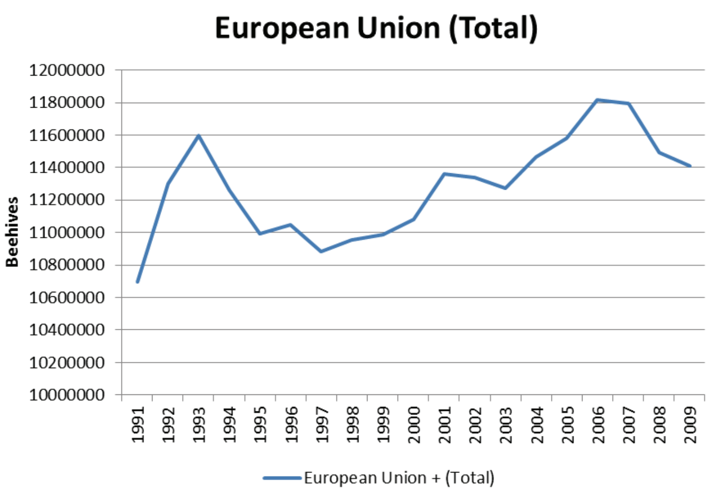
Incident reporting is carefully monitored by regulators, who adapt regulatory processes quickly in response. For example, incidents reported in Germany in 2008 after farmers planted seeds defectively coated with insecticides[28] acted as an "alert" to the risks that may arise from exposure to seed dusts. [29] As a result, risk management measures were put into effect almost immediately in many countries.[30] This incident, together with earlier observations about the generation of dusts at planting under particular circumstances, led to it being included on the list of routes to be considered when defining how ecosystems and pollinating species might be exposed.[31] Similar approaches are being taken in other countries, e.g., in Canada with CANPOLIN (Canadian Pollinator Initiative) and across North America with NAPPC (North American Pollinator Protection Campaign).

Some countries respond to specific incidents. For example, an association between colony losses and PPPs was considered credible and therefore evaluated in 2009 in Greece. The study, published in 2010 by Bacandritsos et al. (2010), was unable to identify a single specific cause behind the deaths.

The Economics of Beekeeping in Europe

Evidence also suggests that a fall in the number of managed honey bee colonies may simply be linked to a drop in the number of beekeepers in Europe. Though beekeepers increased the number of colonies they maintained between 1965 and 2005 in Southern Europe, especially in Greece, Italy and Portugal, the overall trend has been a decline,[32] with numbers in Central and Western Europe falling since 1965.

Figure 3. Number of beehives in countries belonging to the EU. Data Source: FAOSTAT



The European Commission Communication on Honey Bee Health estimates that about 700,000 beekeepers are now tending some 15 million hives in the EU. About 97% of these beekeepers are non-professionals who maintain about 67% of EU hives. The greatest numbers of hives are found in Spain (2.46 million), followed by Greece (1.5 million). France, Italy, Poland and Romania each have more than a million.

In trying to explain the decline, it's important to ask what motivates people to tend hives in the first place. Keeping bees on a small scale, for instance, frequently fails to make economic sense. The price of materials and disease treatments are high and costs often exceed income.

28 Pistorius et al., 2009
29 Foster, 2010, Nikolakis et al., 2009
30 JORF, 2009, BVL, ZALF, 2009
31 EC, 2009-annexes
32 ECPA, 2011 Pollinators and Agriculture

Hobby beekeepers are not then usually driven by economic incentive. Profit is however essential for professional and semi-professional beekeepers: studies worldwide show that the relative profitability of beekeeping is likely to have a major influence on the number of managed colonies.

This profitability, in turn, likely rests on honey. While pollination services are a source of income for many professional beekeepers in the US, e.g., in almond farming, beekeepers are rarely paid for such services in the EU and income is mainly generated from the sale of hive products. European countries produce about 200,000 tons of honey a year.

Honey Price Evolution

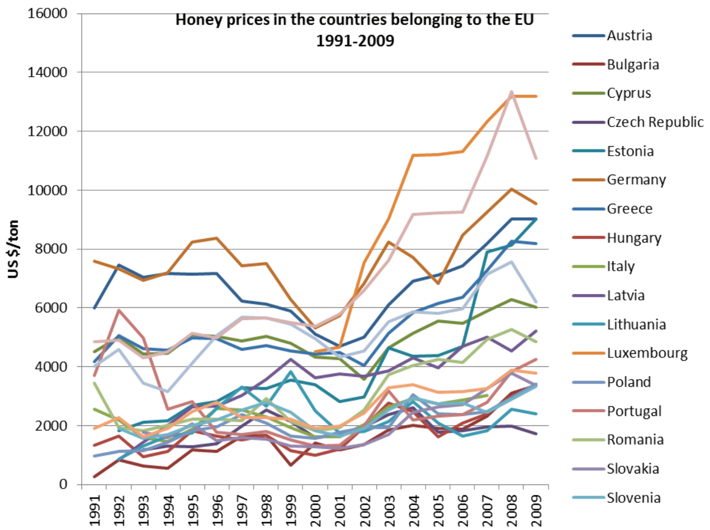
An analysis of Food and Agriculture Organisation (FAO) honey data available for EU countries between 1991 and 2009 gives us some insight into the economics and challenges of beekeeping.

In broad terms, the price evolution of honey during the period 1991-2009 was similar for all countries now belonging to the EU. A slight price increase can be observed until 1997 – 1998. This is followed by a sharp decrease to even below the level of 1991 in many cases (Austria, Cyprus, Germany, Hungary, Italy, Portugal, Romania, Slovakia and Slovenia). After 2001, the price rose or remained relatively stable until 2007, when we again see a general tendency towards a fall in all countries.

The accession of new member states to the EU has not made any significant impact on the price gap in Europe. FAO data also show that countries now making up the EU have maintained a relatively constant negative balance for honey, being unable to cover roughly 1/3 of honey consumption by production over the period 1991-2007.

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. In the EU, for countries in Southern and Eastern Europe, the price varies generally in the range of $1500-$3000/ton. For Northern European countries the average price is in the range of $3000-$6000/ton and for the Western European countries, the price has fluctuated generally between $6000 and $8000/ton in the reference period.

Figure 4. Honey prices in the countries belonging to the EU. Data Source: FAOSTAT



What's the correlation?

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

Better honey prices for European producers and a support program financed by the European Commission began to strongly influence stocks in 2001 and there was a strong increase in the total number of beehives before 2007. The lower price of honey has had a negative influence on the profitability of beekeeping since 2007, and this has, in turn, generated a sharp decrease in the number of beehives, which have fallen 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. EU financial support, which partially compensated the costs of fighting bee pests, served to increase stocks.

The overall picture mirrors the situation in other countries such as the US, where colony declines prior to the introduction of *Varroa* were linked to stagnant honey production figures. Increased colony productivity in the same period has been used to explain increasing numbers of managed colonies in Canada.

CHAPTER 3. RECOMMENDATIONS FOR IMPROVING BEE HEALTH

Scientists have shortened the list of stressors that may be causing bee deaths, and research is now focused on the interaction of several factors. Even without definitive answers, we have enough information to take some steps towards protecting pollinators. The recommendations below concern all those involved in agriculture, beekeeping, regulation and research: it is essential that the recommendations are widely communicated because their effectiveness relies on joint implementation.

Treatments Against *Varroa*

The first recommendation is to promote the development of new treatments against *Varroa* because only a small number of approved Varroacides are commercially available for beekeepers. *Varroa* mites have also developed resistance against treatments in some regions.

Beekeeping practices, climatic conditions and different seasonality also influence how well treatments work. Treatments also need to be used carefully to avoid hurting bees and to prevent residues in honey and the hives. It is therefore critical that beekeepers are both well informed about the identification and biology of diseases and aware of the strengths and limitations of different methods of treatment.

In addition to the development of new Varroacides, some thought should be given to fighting pests that haven't yet arrived in Europe. Within the coming years or decades, we expect pests such as the Small hive beetle *(Aethina tumida)* or *Trolilaelaps* mites to appear and spread. We observed this same scenario with *Varroa*.

Training for Beekeepers

Modern beekeeping is a complex activity that requires extensive knowledge of the biology and behaviour of bees, medical treatments for their diseases and techniques for re-queening colonies. This knowledge is essential to keeping bees healthy during the whole year and to maintaining strong colonies that have enough food to live through the winter. Knowledge of honey production, storage, food safety issues and hygiene is also part of good beekeeping and growing more critical in terms of meeting stringent market needs.

We need to promote regular training: manuals and guidelines for beekeeping practices and hygiene procedures should be a priority. Developing professional standards would stimulate the implementation of these practises.

We have also seen that migratory beekeeping can contribute to meeting nutritional needs of healthy bees; policy therefore needs to promote it.[33]

Economic Support for Honey Production

Professionalization of beekeeping should be accompanied by economic support for honey production. We have seen that beekeeping is generally unprofitable: such support is essential to compensating beekeepers for their high costs in controlling and eradicating bee pests. Competitiveness of European beekeeping on the world market should be a key policy concern.

There is also a large gap in honey prices between different parts of the EU. This is likely because honey markets are usually locally oriented. Greater emphasis should then be put on ensuring a better functioning of the internal EU market for apicultural products. Honey producers should be better able to take advantage of opportunities offered by the internal market.

Improved Agricultural Practices

The decline in the number of bees in agricultural areas is clearly linked to farming practices. Habitat conservation and management are key aspects of reversing the decline, as is the appropriate use of pesticides.

Some land management practices, such as replacing flower-rich meadows with crops or meadows that provide little or no resources for bees during the summer months, do not favour bees. By contrast, agricultural land use practises such as planting flower-rich meadows, orchards, hedges, flowering crops, field margins and buffer strips can all provide valuable food sources and habitats.

Actively sown pollinator strips, a land-use practice aimed at benefitting pollinators, has been shown to attract to wild bees and other pollinators.[34] Using buffer margins around crops to reduce spray and dust drift onto neighbouring fields and habitats may also protect biodiversity and bee food sources.

Cropping regimes can also have a significant impact on bees. Rotating land use from one crop to another provides seasonal diversity in pollen sources as a result of more diversity and the growth of flowering plants that benefit bees. [35]

Use of Pesticides

Pesticides are an important means of controlling insect pests, weeds and diseases on farms and in urban landscapes. Following label directions is the best way to protect pollinators and, at the same time, failure to do so is what most often leads to significant, isolated effects on bee populations.

There are many recommendations for proper pesticide use and good stewardship practices that help mitigate the potential for harm to pollinators. General recommendations for protecting bees and pollinators can be organised into categories such as minimising off-site drift of sprayed and seed treatment materials, understanding pollinator visitation habits and, finally, cooperating and communicating with others, particularly beekeepers.

Risk management options for the safe use of certain pesticides should also be better communicated among and within EU Member States so that knowledge and technical improvements can be shared and put into practice quickly.

33 The European Commission and the European Council have put forward recommendations for the implementation of quality training in member states and have identified them as a priority (COM(2010)714final; 8606/1 ADD01REV1).
34 Carvell et al., 2007
35 ELO/ECPA/RifCon/E-Sycon

CHAPTER 4. CALL FOR CONTINUED RESEARCH AND MONITORING

Increasing demands for food and fibre have led to important changes in the agricultural landscape over the past centuries and the possible impact on fauna has been a subject of concern for the past decades.

With regard to the honey bee, the past 20 years have seen the implementation of incident reporting systems, active hive monitoring, multi-factorial research studies and post-approval studies of pesticides. Together, they have made significant contributions to our understanding of honey bee health across Europe. We've found that:

- Honey bees can cohabitate with modern agricultural practices as long as we take precautions to maintain viable food resources and avoid practices that may cause adverse effects;
- The health of honey bees, evaluated by indicators such as overwintering mortality, the presence of pests and diseases or honey production, relies on many factors including the availability of veterinary products;
- Indicators such as the number of apiaries, beehives or beekeepers give more limited information about bee health. This is because they are strongly affected by local and global economies, the numbers of professional beekeepers and market prices;
- Honey bee health may be affected by a multitude of factors. Agricultural practices may contribute to the weakening of bee colonies, which may then become more vulnerable to pests and diseases;
- Attempts to rank factors in terms of how big an impact they have on bees has resulted in the following order: pests and diseases; habitat loss; land fragmentation; loss of nutrition sources; poor beekeeping and agricultural practices and poisoning. This should be interpreted with caution because it may vary between and within countries;
- Designing agricultural landscapes and implementing practices that account for the presence of pollinators is effective in limiting the impact on the population to a negligible level;
- Veterinary compounds are lacking or insufficient to help beekeepers eradicate the most important pests from apiaries. Similarly, little support is given to collective action against pests and diseases.

Though we have a far better picture of honey bee health throughout Europe and abroad, there are still significant gaps in our knowledge. Scientists are addressing them in projects such as those listed below:

- *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*

Taken together, the programs will improve the understanding of the nature, causes, and consequences of bee deaths and will identify ways of slowing or halting pollinator deaths at local, continental and global scales.

More research activities, including those on bee pests, diseases and on pesticides, and their potential interactions, are nonetheless critical towards developing appropriate measures for avoiding or limiting potential damage. We also need more research into the economics of beekeeping. While Europe has around 20% of the estimated global number of honey bee hives, little or no information can be found on economic aspects and challenges of beekeeping in the region overall. As pointed out by the professional association COPA COGECA, marketing problems are related to the lack of information, including statistics and forecasts, on the market.

And while there is a wide variety of monitoring and surveillance systems in Europe, they need to be improved, harmonised and standardised.[36] Much work is already being done towards this goal. The Coloss Network plans to publish a "Bee Book," which will define international standards for large-scale monitoring and research activities. The broad approach will improve detection, understanding, and the mitigation of drivers of bee deaths. The European Commission has also designated an EU Reference Laboratory for issues related to bees. The main task is start an EU-wide pilot project to assess the situation and then to propose a framework for a harmonised monitoring system.

Research and monitoring activities should be more balanced between wild and managed bees. The ecology of wild bees, their sensitivity to pathogens and other stressors should be investigated to ensure that agricultural practices and risk management measures protect them adequately.

Finally, we cannot overemphasise the importance of communication. We have found a general lack of communication both between farmers and beekeepers and between these agricultural actors and people in scientific and regulatory roles. Modern agriculture and beekeeping require better technical knowledge and skills, including input from scientists and regulators: all groups should work together to improve to communication and overcome elements of mistrust.

36 Hendrikx et al., 2009; EFSA, 2009

Prof. Ettore Capri
Director of OPERA Research Centre
Universita Cattolica del Sacro Cuore
Via E. Parmense 84
29100 Piacenza
Italy
Ph. +39 0523 599 218
ettore.capri@unicatt.it

Alexandru Marchis Policy Team Coordinator
OPERA Brussels Office
Place du Champs de Mars 2
1050 Brussels
Belgium
Ph. +32 (0)2 518 7683
alexandru.marchis@operaresearch.eu

OPERA
RESEARCH CENTER

info@operaresearch.eu
www.operaresearch.eu