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# Bee health in Europe - Facts & figures 2013

*Compendium of the latest information on bee health in Europe*

Bridging science and policy

UNIVERSITÀ CATTOLICA del Sacro Cuore

OPERA would like to thank all the members of the OPERA Bee health working group: **Dr. Ettore Capri**, OPERA Research Centre; **Dr. Mariano Higes**, Laboratory of Bee Pathology of Centro Apícola (JCCM), Spain; **Dr. Konstantinos Kasiotis**, Benaki Phytopathological Institute, Greece; **Dr. Kyriaki Machera** Benaki Phytopathological Institute, Greece; **Alexandru Marchis**, OPERA Research Centre; **Dr Stephen J. Martin**, Salford University, UK; **Jens Pistorius**, Julius Kühn-Institut, Germany; **Thomas Steeger**, Environmental Protection Agency, U.S.A; **Dr. Helen Thompson**, National Bee Unit, UK and **Selwyn Wilkins**, National Bee Unit, UK; for their substantive input, constructive attitude and valuable suggestions made for the development of the report, as well as the technical contributors: **Dr. Anne Alix**, Dow AgroSciences; **Dr. Peter Campbell**, Syngenta; **Jean-Paul Judson**, European Seed Association; **Dr. Christian Maus**, Bayer Crop Science; **Mark Miles**, Dow Agrosciences; **Amalia Kafka**, OPERA Research Centre; **Yvonne Kent**, BASF Crop Protection; and **Chiara Corbo**, OPEARA Research Center, who shared with the group their evaluations, analysis, insights and valuable expertise.


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

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# Bridging science and policy

*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. 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.*

# FOREWORD

A decline in the population of honey bees continues to be a source of concern in many regions of the world. It's no surprise that with so much potentially at stake—reduced pollination by bees could reduce the biodiversity and disturb the stability of the ecosystem, damaging prospects for Europe's farmers, agribusinesses and the whole of the society—researchers continue looking for answers while politicians seek solutions based in policy.

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 the scientific community.

The report "Bee Health in Europe – facts and figures" moves from the newest data from scientific research into drivers of bee health and presents the latest figures in the trend in bee population and reports initiatives and policies being developed in Europe and abroad.

The objective of the working group producing this report was to build on the findings of the previous OPERA report, published in 2011, to include state-of the art information and research results on the issue of honeybees in agricultural systems and collect in one single comprehensive document relevant data on bee health.

Collecting and analysing the existing evidence and information to identify the main factors influencing bee health will help to further adjust research and policy priorities to protect bees.

Highlights include the developments in EU relevant policies and regulatory framework for pesticides and veterinary medicines; recent studies or evaluations on the impacts of pests and diseases like the Varroa destructor and the associated Deformed Wing Virus (DWV); the importance of beekeeping practices; data on the economics of beekeeping in Europe and measures being taken to make it a more attractive pursuit; and need for foraging habitat for bees.

We are very much grateful for the efforts that the members of the working group have put in the development of this report. We have had the chance to work with outstanding scientist and experts in various areas of bee health and the comprehensive collation of their extensive knowledge and expertise is definitely the main value added of the paper.

As OPERA, we are proud to have provided the platform and support for the activity of the working group and contributed to the general objective to provide a clear image on the issue of bee health and to recommend a series of elements for policy decisions.

More work is clearly needed and bee researchers and agricultural policy makers are continuing to forge ahead at a rapid pace. We look forward to sharing all the newest information in future reports.

**Ettore Capri**
*Director of the OPERA Research Centre*

# CONTENTS

# EXECUTIVE SUMMARY

Many regions of the world, including Europe, have recorded honey bee losses in recent years. These deaths are of great concern, because declines in bee populations may have significant and far-reaching consequences. They could affect for some crops pollination and disturb the stability of the agricultural ecosystems, which also damages European farmers' prospects, agribusiness and the whole of society.

Research organizations and governments have therefore introduced national monitoring schemes and conducted numerous studies. It is, however, still difficult to explain the losses. In particular, the European Food Safety Agency (EFSA) found that honey bee health surveillance systems in Europe are "highly variable and generally weak". Few countries have reliable data and it is hard to quantify losses properly. Surveillance systems vary so much that data cannot be compared in any meaningful way.

With so much potentially at stake, including food security, policymakers are eager to take action. Halting the loss of biodiversity by 2020, a move likely to benefit all kinds of pollinators, is one of the European Commission's (EC) main objectives. The EC has also designated a reference laboratory for bee health, a decision meant to improve the quality of collected data and to harmonise surveillance. Risk assessment procedures for plant protection products are also being revised.

Improvements are clearly being made. We release this report now in an atmosphere of emerging knowledge and continuing research. With it, we describe reported bee population trends, discuss explanatory factors, outline on-going initiatives and finally recommend additional steps.

## Trends in honey bee populations

Honey bee data comes from many sources, including the Food and Agriculture Organisation (FAO), the scientific network COLOSS (Prevention of honey bee COlony LOSSes), national apiculture programmes and national beekeeping organisations. The figures vary greatly from country to country, with FAO data indicating an overall increase in the total number of beehives managed in Europe for 2009-2010.

As for the winter losses, the parameter to characterize the weakness of the colonies, COLOSS data from the same period allow countries to be classified into three categories. Low colony losses were seen in countries including Croatia, Slovakia, and Norway; moderate losses were seen in Germany, Denmark and Northern Ireland, while high losses were reported in Ireland, the Netherlands and Switzerland. The average winter losses per country where data were reported for the period 2008-2012 varied between 7% and 30%.

Some countries also provide information on bee incidents that may be linked to the use of agrochemicals. The trends here show that the numbers of pesticide-related bee incidents are declining in some countries such as Germany and France, which is likely to be due to improved methods of applying pesticides.

## Beekeeping practices and impact on bee welfare

Data from COLOSS show an interesting aspect of bee mortality—in most countries, hobby beekeepers managing 1 to 50 colonies reported higher losses than beekeepers managing larger number of colonies. It is clear then that beekeepers themselves play a critical role in maintaining bee health. Knowledge of bee biology, beekeeping techniques, disease biology and treatments as well as suitable equipment is essential.

In many European countries, the majority of beekeepers pursue this activity as a hobby. For example, in Germany 80% of beekeepers keep just 1–20 colonies, 18% keep 21–50 colonies and only about 2% keep more than 50 colonies. Improved expertise and education are likely to have a significant impact on bee health. Better beekeeping and state-of-the-art equipment would lead to healthier bees, higher quality and increased volumes of bee products, easier data collection and improved disease treatment.

## Threats to bee health

That said, even the most experienced beekeeper may not be able to protect bees from other threats. We don't yet have sufficient knowledge to give definitive answers about what causes colony losses, but researchers have identified a number of factors that can impact honey bee health. They include pests and diseases, pesticides, beekeeping methods, agricultural practices and climate.

## Pests and diseases

Honey bees are susceptible to a number of pests and diseases. Research suggests though that the main culprits behind colony losses are the Varroa *(Varroa destructor)* American foulbrood, European foulbrood, *Nosema spp*., honey bee viruses and Acarine mites *(Acarapis woodi)*. Sometimes it's a need for better beekeeping practices.

Varroa is not only damaging on its own, it has also irreversibly changed the Deformed Wing Virus (DWV) viral landscape across the world. DWV is according to very recent evaluations the most likely candidate responsible for the majority of the colony losses that have occurred across the world during the past 50 years.

The disease produced by Nosema infection cannot be considered as regionally contained problem but rather a global one. Not only does this type of nosemosis cause a clear pathology on honeybees at both the individual and colony levels, but it also has significant effects on the production of honeybee products.

In addition to these established threats, there are a number of emerging hazards including the small hive beetle *(Aethina tumida)*, an invasive species from Africa, *Tropilaelaps* parasitic mites and the Asian hornet *(Vespa velutina nigrithorax)*.

## Foraging habitat loss

Research also shows that foraging habitat loss is one of the most important factors behind declines in bee numbers. Foraging bees need high quality nectar and pollen from a variety of sources to prevent nutritional deficiency and to strengthen immune defences—areas with high floral diversity are more likely to provide sufficient nutrition throughout the year. Changes in land-use and crop management, as well as a loss of the traditional farming and forestry practices that included rich habitats, lead to a lack of biodiversity.

## Pesticides

Pesticide use is often assumed to play a significant role in bee health. In fact, single poisoning events have been reported in many countries which are, in the majority of cases, linked to the wrong choice of time for spray application, and generally linked to the misuse of products that results in an exposure of honey bees. The misuse of products combined with poor communication with beekeepers are the most frequent cause of adverse effects.

## Genetic diversity and resilience to pests and diseases

Genetic diversity also plays a role in bee health. The European honey bee population is made up almost entirely of colonies managed by beekeepers and selective breeding has resulted in the spread of the commercially most interesting subspecies. Though good for honey production, this has led to a reduction in genetic diversity, which is important for maintaining resistance to disease and overall colony health. What's more, genetically similar colonies may transmit disease more effectively and result in increased colony losses. Selective breeding may have left the bee population more vulnerable to a number of threats.

## Economic factors influencing honey bee populations

Evidence also suggests that a drop in managed honey bee colonies in Europe may simply be linked to a decline in beekeeping—the price of materials and disease treatments are relatively high, so the costs of the hobby may often exceed the income generated, discouraging people from pursuing it. Fixed costs represent in certain cases up to 70% of the total costs, hence small scale beekeeping is often not economically viable. Among the variable costs, the higher share is taken by the costs incurred with the fight against pests and diseases.

A number of national programmes funding an improvement in the production and marketing of apiculture products have been fundamental in offsetting the loss of bees. EU member states and beekeepers are satisfied with the benefits of these programmes. This contrasting evidence shows the importance of weighing all the evidence and the implementing legislative initiative and policies in ways that both protect bees, as well as enhance their health and numbers.

## Initiatives and policies

In Europe, the EC is exploring different possible methods to protect honey bee populations from declines. In the regulatory area of plant protection products EFSA has prepared a draft guidance document on the risk assessment on bees, to ensure that bees are properly protected. The draft guidance document, was recently available for the consideration of the member states as well as stakeholder and public comments.

The EC has designated a reference laboratory for bee health. The EC is also co-financing with the member states a number of national programmes provide support to the beekeeping sector and to collect more accurate data on the status of bee health in Europe.

In the USA a recent white paper from the U.S. Environmental Protection Agency, Health Canada's Pest Management Regulatory Agency and the California Department of Pesticide Regulation describes a new approach for quantifying potential risks of pesticides to honey bees.

## Other initiatives

These governmental efforts are in agreement with the work of a number of international organizations involved in research on honey bees and other pollinators. They include the International Commission on Plant Pollinator Relationships (ICPPR), the European and Mediterranean Plant Protection Organisation (EPPO), the Organisation for Economic Co-operation (OECD)and Development and the Food and Agriculture Organization(FAO).

## Risk management for pests, diseases and pesticides

Risk assessment procedures for pesticides are designed to demonstrate their approved use is compatible with the protection of bees. To ensure that this happens in practice, a number of projects on risk mitigation are also underway. The Status and Trends of European Pollinators (STEP) project, for example, aims to examine the situation for of risk mitigation measures for pollinating species, in a wider perspective, to include all the factors affecting bee health and numbers. This and other research projects help identify better the relative importance of potential drivers, including climate change, habitat loss and fragmentation, agrochemicals, pathogens, invasive alien species, light pollution, and their interactions.

OECD's Pesticide Effects on Insect Pollinators (PEIP) working group is, among other actions, developing a portal that will provide a link to actions and policies regarding risk mitigation measures related to pesticide use in OECD countries.

## CONCLUSIONS

According to FAO data for the period 1992 - 2010, in Europe, the number of beehives has remained fairly constant while the causes for the fluctuations between years are not easily identifiable.

COLOSS reports that between 2008 and 2012, winter losses ranged from 7 to 30% with variations between countries and between years for the same country. No clear overarching trend can be highlighted.Beekeeping practices and the materials used, such as the type of hive, can be of high importance for the well-being of bees.

A number of pests and diseases have been demonstrated as being implicated with colony losses. The major pests/diseases are *Varroa destructor,* American foulbrood, European foulbrood, Nosema spp., honey bee viruses, and Acarine mite *(Acarapis woodi). Varroa* has irreversibly changed the Deformed Wing Virus (DWV) viral landscape across the world. DWV is now considered one of the key players in colony losses in Europe. Future threats and non-native invasive species are also of high interest, like the Small Hive Beetle *(Aethina tumida), Tropilaelaps* spp. (another parasitic mite) and the Asian Hornet *(Vespa velutina).* 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 be relevant where the regular risk assessment still contains uncertainties.

International organizations like FAO, OECD, and ICPPR have developed a series of activities to address issues related to Bee health. The European Commission has designated a European reference laboratory for bee health; is co-funding national programs to support beekeeping and to collect data on bee health as well as revising risk assessment procedures for pesticides.

## RECOMMENDATIONS

- Due to the multi factorial nature behind the causes of colony collaborative work between the various disciplines is necessary to resolve the issues.
- An analysis of the factors influencing the number of colonies in each country is necessary as trends vary between them.
- Focus on improved beekeeping practices and the implementation of risk mitigation practices.
- Promote the communication and training of good beekeeping practices and programs co-financed by the EU to support the apiculture sector should be continued.
- Continue research on pathogens, diseases, pests and veterinary products.
- Continue to develop risk mitigation methods for the safe use of pesticides and education of pesticide users to understand the approved conditions of use.
- Promote landscape management practices that are proven to be effective to promote bee health.
- Promote the research on the genetics of managed and feral honey bees

## WORKING GROUP MEMBERS

**Dr. Ettore Capri**, Professor and Director of the Research Centre OPERA. He is a member of different working groups in national and international authorities dealing with the development of guidelines for research in the field of the contaminants fate in the environment, the risk assessment and the development of strategies for implementing sustainability approaches in practice. Since 1990 he published more than 200 international papers and coordinated 45 international projects.

**Dr. Mariano Higes** Director of the laboratory of Bee Pathology of Centro Apícola (JCCM, Spain). For more than 20 years dedicated his work to the study of the major diseases of bees, pioneering work in Nosema ceranae and its relationship with the loss of bee colonies. He is a member of different working groups in national and international authorities. Since 1990 he published more than 100 international papers and coordinated 40 research projects.

**Dr. Konstantinos M. Kasiotis** holds a B.Sc. in Chemistry and a Ph.D on medicinal chemistry. In 2007 he joined Laboratory of Pesticides Toxicology of Benaki Phytopathological Institute where he is currently a Research Assistant. He is involved in pesticide residue analysis in bees, pollen, honey and other matrices such as biological fluids, personal protection equipment and marine organisms. He has 23 publications in peer reviewed journals.

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**Alexandru Marchis,** has as academic background is in agricultural economics and he also holds two post university degrees, in agro-business and in diplomatic international relations. He was previously Counsellor for European Affairs in the Ministry of Agriculture in Romania and then as Agricultural Attaché for the Permanent Representation of Romania to the EU. Since 2010, he is coordinating the Brussels office the OPERA think-tank.

**Dr Stephen J Martin**, DSc, FRES (Reader in Animal Ecology, Salford University, UK). Spent seven years (1984-1991) in Japan studying hornets. Followed by seven years (1993-2000) working at the National Bee Unit on honey bee pests and pathogens including Varroa and viruses. Return to university in 2001 to continue research into chemical ecology of social insects and pests and pathogens of honeybees. Have a 100+ peer review papers that are currently cited over 200 times a year.

**Jens Pistorius** is working at the federal German risk assessment authority and federal research Julius Kühn-Institute, as Head of risk assessment of PPPs on honeybees, Head of examination centre for bee poisoning incidents and federal research activities on pesticides and bees since 2007. Before he worked at a private research institute as study director for honey bees. Next to the scientific work he is also a beekeeper.

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**Dr. Helen Thompson** is an ecotoxicologist and leads the Environmental Risk Team at the Food and Environment Research Agency. She worked for FERA since 1989 including 4 years as the laboratory technical manager in the National Bee Unit. She has over 70 peer reviewed publications in terrestrial ecotoxicology and is secretary of the ICPBR Bees and Pesticides working group.

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## TECHNICAL CONTRIBUTORS

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**Dr. Peter Campbell** has 21 years experience in regulatory ecotoxicology. He is the acting President of SETAC Europe and Senior Environmental Risk Assessor and Head of Product Safety Research Collaborations at Syngenta, responsible for leading Syngenta's Honeybee Research Portfolio.

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**Mark Miles** He has over 20 years experience in studies and related risk assessments for all aspects of terrestrial invertebrate ecotoxicology. He is a member of several ICPBR working groups, the co-chair of the SETAC EMAG-Pest group for monitoring of invertebrates. Mark is a Chartered Member of the Society of Biology, while he is the global lead scientist for bee, pollinator and non-target arthropods issues and soil ecotoxicology within Dow AgroSciences.

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**Chiara Corbo** graduated in Management at the University of Bari, Italy. She completed a master degree in Marketing. Currently, she is concluding her PhD in "Agrisystem" at the Università Cattolica del Sacro Cuore. She works on projects related to the Sustainable Development, with a focus on the sustainable use of resources (especially water and biodiversity). In September 2012 she joined the OPERA office in Brussels.

# CHAPTER 1. INTRODUCTION

Within recent years many regions of the world, including Europe, beekeepers have experied higher than usual colony losses. It cannot be excluded that these losses may have serious economic and ecological impacts, for example by reducing honey bee pollination services. The reasons for many of these bee losses remain uncertain.

A comprehensive study into Bee Mortality and Bee Surveillance by the European Food Safety Agency (EFSA, 2009) concluded that honeybee health surveillance systems in Europe are 'highly variable and generally weak'. As a result, few countries have any reliable data to allow losses to be properly quantified. Differences between national surveillance systems are so great that available data cannot usefully be compared between Member States; hence the EU has taken the decision to designate a European Reference Laboratory for Bee Health *(see Chapter 6.1.)*.

## 1.1 Pollination and agriculture

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 much higher around 20 billion € (Gallai *et al.*, 2009).

The modern day prevalence and distribution of bees in the agricultural landscape has been very much shaped by human behaviour. Bees are mainly attracted to crops by nectar and pollen. Many modern crops provide these essential resources for both wild and domestic bees. 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. Production of 39 of the leading 57 crops world-wide is enhanced by visits from pollinating animals, which in aggregate accounts for 35% of global food production (Klein *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, crops or meadows provide little or no resources for bees during the summer months.

In contrast, some agricultural land use practises can favour bees, 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).

## 1.2 EU Policy context

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. Change 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 of biodiversity loss.

*"Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss"* is the main objective of the European Commission's strategy for biodiversity published in 2011.

Among others, one of the actions decided by the Commission to achieve that objective is to maximise areas under agriculture that are covered by biodiversity-related measures under the CAP so as to ensure the conservation of biodiversity and to bring about a measurable improvement. Such action is aiming at enhancing plant biodiversity, but also in improving habitat conditions for animals and insects.

At a European level institutions and stakeholders have raised their concerns on loss of biodiversity: this is broadly demonstrated by a wide range of initiatives in order to promote the biodiversity's level monitoring and the creation and use of indicators.

Also, the process of reform of the Common Agricultural Policy (CAP) aims to maintain and enhance the level of biodiversity, especially through the promotion of specific agricultural measures. In the EU Commission proposals to reform the CAP the so called "greening measures" will be included in the eligibility criteria for part of the direct payments:

- Allocation of 7% of agricultural land for Ecological Focus Areas;
- Crop diversification: minimum 3 crops per farm;
- Preservation of permanent grassland.

Still, political discussion around the upcoming reform of the Common Agricultural Policy (CAP) has shown that there is a clear need to better understand what is meant with "greening" and how this will be put in practice.

In the same proposals to reform the CAP, the Commission acknowledges that beekeeping is characterised by the diversity of production conditions and yields and the dispersion and variety of economic operators. The commission recognises that this needs to be addressed within policy instruments. An additional driver for continued action is the increasing negative impact on bees and beekeeping caused by varroosis.

Given such circumstances national programmes co-financed up to 50% by the EU funds, could be drawn up and implemented every three years by the Member states *(see Chapter 6.5. for further details).*

These policy objectives are also relevant from the point of view of enhancing pollination as one of the important ecosystem services. In its strategy on biodiversity, the Commission states that the continued decline in bees and other pollinators could have serious consequences for Europe's farmers and agri-business sector.

# CHAPTER 2. TRENDS IN HONEY BEE POPULATION

## 2.1 Number of beehives in Europe

According to FAO data, 16 million of bee hives exist, on average, in Europe for the period 1992 - 2010 (FAO, 2012). The number of beehives remained fairly constant in the past decade with a slight increase between from 2000 to 2006 (Figure 1).

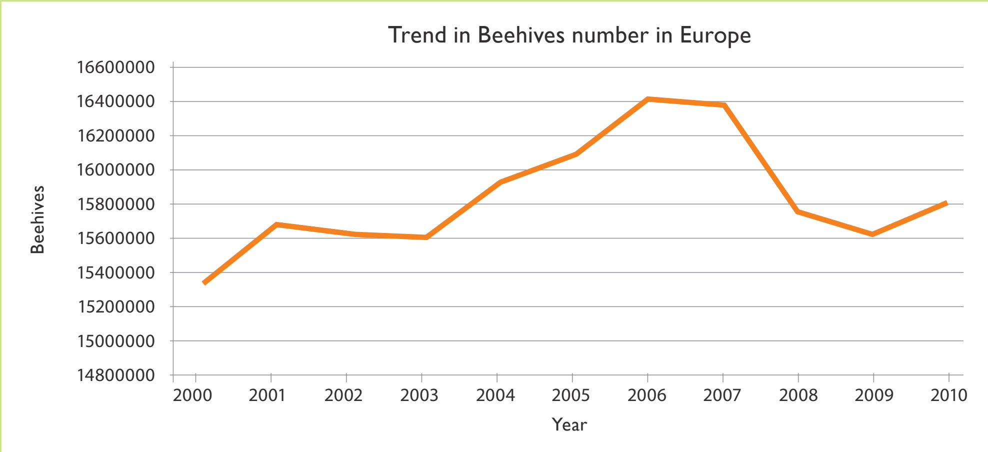


*Figure 1. Beehives in Europe (Source: FAO, 2012)*

Within the EU 27, the greatest numbers of hives are in Spain (2.5 million), Greece (1.5 million) and France (1.3 million) followed closely by Romania, Italy and Poland.

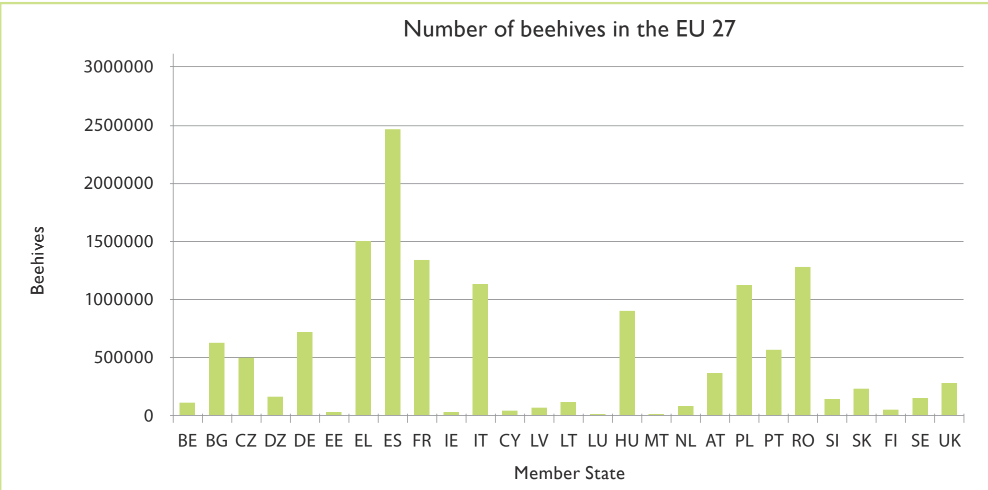


*Figure 2. Number of Beehives in the EU member states (Data source: European Commission, 2010)*

The causes for the fluctuations in numbers over the years are not easily identifiable. Decrease in the number of bee hives may be attributed to climatic conditions, pests and diseases or simply to economic conditions making beekeeping less profitable – there is a clear link between the development of hive numbers and number of beekeepers in many countries. Better honey prices for European producers and the support program financed by the European Commission since 2001 may have stimulated an increase in the bee stocks, however, this is not the only influencing factor.

## 2.2 Colony losses

### 2.2.1 COLOSS project

COLOSS (Prevention of honey be COlony LOSSes) is a scientific network created in 2008 focused on the prevention of honeybee colony losses. It gathers scientists, veterinarians, beekeepers, and students from over 60 countries and facilitates the sharing of knowledge through the organisation of conferences, workshops and joint research projects. One of the key aims of the organisation is the production of the *BEEBOOK* - a manual of methods for honey bee research.

COLOSS has developed a honeybee losses questionnaire. Many countries have implemented this questionnaire, which has enabled direct comparison of colony loss data collected from different National surveys. The latest published colony loss information from these surveys is for the seasons 2008-2009 and 2009-2010. Twelve and 24 countries participated in the survey in each season, respectively.

The information published in the framework of COLOSS relies on the accuracy, perception and rate of participation of beekeepers submitting replies to questionnaires. Hence, conclusions on the possible causes for losses need to be interpreted carefully as they represent the perception and assessment of the beekeeper on what happened to his colonies.

COLOSS reports that in both seasons and in most of the countries the losses identified by hobbyist beekeepers (1-50 colonies) were higher than those experienced by beekeepers with operations of intermediate size (51-500). It is also noted that in countries participating in both surveys, the winter losses of 2009-2010 were higher than those of 2008-2009. However, in 2009-10, winter losses in South East Europe were at such a low level that it could be that the factors causing the losses in other parts of Europe were absent.

The data reported within COLOSS of 2008-2009 are taken from 9,471 operations with a total 172,252 colonies. The results allowed a classification of the countries in two groups

1. those with low mean colony loss (<15%): Austria, Switzerland, Germany, Poland, Denmark, Norway, Sweden
2. those with higher mean colony loss: Belgium, the Netherlands, the UK and Ireland

More specifically, Norway and Denmark appeared to have the lowest colony losses, 7.1% and 7.5% respectively and Ireland and the Netherlands the highest 21.7%. Belgium and UK also have higher colony losses, 18.0% and 16%. The average honey bee losses in Europe varied widely, between 7-22% over the 2008-9.

14,958 beekeepers participated in the 2009-2010 survey. The results allowed a classification into three categories this time:

1. low colony losses in the Republic Macedonia, Croatia, Bosnia and Herzegovina, Slovakia, and Norway
2. moderate losses in Austria, Germany, Poland, Denmark, Northern Ireland
3. high losses in Ireland, Belgium, Netherlands, Switzerland and Slovenia.

The minimum winter losses were seen in the Republic of Macedonia, 6.8%. Slovakia and Croatia also had low losses 7.4%. In Austria and Poland the winter losses were 14.7% and 15.3% respectively and the highest losses were observed in Belgium, 26% and the Netherlands 29.3%. The average winter losses for the season 2009-2010 varied between 7-30%.

The losses reported for Finland, England and Wales, Italy, Scotland, Spain and Sweden were so variable that the mean losses could not be considered representative, so these countries could not be classified into any of the above mentioned categories.

| Country | Number of Operations | Total number of colonies in October | Median Number of colonies in October (interquartile range) | Mean winter loss % (95% CI) |
|---|---|---|---|---|
| Austria | 224 | 4,920 | 12 (6-28) | 14.7 (11.2-18.3) |
| Belgium | 210 | 2,282 | 8 (5-14) | 26.0 (19.2-32.7) |
| Bosnia & Herzegovena | 268 | 15,286 | 50 (22-78) | 8.6 (6.9-10.3) |
| Croatia | 907 | 90,388 | 80 (50-120) | 7.4 (6.5-8.3) |
| Denmark | 618 | 11,433 | 8 (4-16) | 15.1 (11.5-18.7) |
| England & Wales | 564 | 14,580 | 4 (2-10) | 17.5 (9.3-25.6) |
| Finland | 40 | 4,069 | 45 (13-118) | 19.6 (7.5-31.6) |
| FYROM | 118 | 6,642 | 41 (29-72) | 6.8 (4.9-8.6) |
| Germany | 4,032 | 55,560 | 9 (5-15) | 18.3 (17.1-19.4) |
| Ireland | 381 | 3,527 | 4 (2-10) | 22.4 (17.0-27.8) |
| Italy | 113 | 3,560 | 16 (8-30) | 29.8 (12.7-47.0) |
| Netherlands | 1,315 | 11,107 | 5 (3-8) | 29.3 (22.8-35.7) |
| Northern Ireland | 99 | 435 | 2 (1-7) | 14.1 (8.9-19.4) |
| Norway | 146 | 5,817 | 17 (9-38) | 8.8 (6.5-11.1) |
| Poland | 281 | 12,145 | 30 (15-56) | 15.3 (12.0-18.7) |
| Scotland | 111 | 4,233 | 3 (2-7) | 25.5 (0.5-50.4) |

*Table 1: Mean winter colony losses per country in 2009-2010 (van der Zee et al., 2012)*

Survey on losses conducted in 2010-2011/2011-2012

At the recent Working Group 1 COLOSS workshop which took place in October 2012 in Poland, the data for several of the countries using the COLOSS survey in 2011-12. The losses observed in Ireland for 2011-2012 were 13%, while during 2010-2011 they had been slightly higher at 17%. In Poland the participation of beekeepers in the survey was low, 1.6% and 1.3% respectively. Nevertheless the data that was published indicate losses of 18.1% for 2010-2011 and 15.8% for 2011-2012, although in some regions they exceeded 30%. In the case of Austria the losses for 2011-2012 were the highest so far, 25.9%. Brodschneider & Crailsheim (2013) show losses of 16.4% for 2010-2011 in Austria. The survey data collected in Sweden though showed losses of 12.1% for 2011-2012.

### 2.2.2 Colony losses in Germany between 2008 and 2012

In Germany, there are in principle two different activities used to get information on the number of annual colony losses; the losses are documented in the large-scale German Bee Monitoring project that is on-going since 2004. Interim results on overwintering losses published by Genersch *et al.*, (2010) concluded that several factors were significantly related to the observed winter losses of the monitored honey bee losses, e.g. high Varroa infestation level, infection with deformed wing virus and acute bee paralysis virus (ABPV) in autumn, queen age and weakness of the colonies in autumn (Genersch *et al.*, 2010).

The losses across the various regions of Germany are also annually surveyed by DLR/FBI Mayen using anonymous questionnaires. The questionnaire was published yearly in national beekeeping journals and the newsletter of the German association of beekeepers (Deutscher Imkerbund) as well as via the newsletter and the website or sent by post to all beekeepers in Rhineland-Palatinate and North Rhine-Westphalia.

As completion of the questionnaire is voluntary, the collection is not necessarily completely representative. The data on the number of the measured losses for Germany 2008-2012 presented in the following table were calculated for each region by dividing the number of colonies in the fall and the number surviving colonies in each region (Otten, pers. com.).

| | |
|---|---|
| 2008/09 | 11,0% |
| 2009/10 | 18,6% |
| 2010/11 | 16,3% |
| 2011/12 | 22,6% |

*Table 2. Colony losses in Germany between 2008 and 2012 (questionnaire Mayen)*

### 2.2.3 Colony losses in France between 2008 and 2012.

Colony losses in France are documented in a 2011report from ITSAP (Technical and Scientific Institute on Beekeeping and Pollination) . For 2012 data were issued in a separate report prepared in the context of the surveys implemented by COLOSS (ITSAP, 2012, van der Zee *et al*., 2012).

ITSAP has carried out the survey in coordination with regional associations (ADA: Association for the Development of Beekeeping). From 2008 to 2011, data collection was implemented on beekeepers randomly selected from ADA's membership list, to represent 20% of the membership lists. Only beekeepers running 150 hives or more were included in the data collection. The collection of data was based on a questionnaire that covers the purpose of beekeeping (pollination or honey production), beekeeping practice, overwintering method, bee feeding issues, the presence of pathogens and the environment in which bees are placed.

The response rate was *ca* 20% in 2008, and dropped to 15.9% in 2010 and 12.1% in 2011.

The number of losses used by the institute included dead colonies, weak colonies, colonies with failing or drone laying queens and queenless colonies. The percentage of each category into colony losses is not reported. Results are also corrected on the basis of the response rate of each ADA divided by the number of beekeepers of that region.

*Table 3.Colony losses in France as measured in spring 2008 to 2011 in randomly selected beekeepers, corrected to avoid bias related to the participation rate of beekeepers for each region.*

| Winter | % colony losses at the national level | 95% confidence interval |
|---|---|---|
| 2008 | 29.2% | [26% - 32%] |
| 2009 | 23.3% | [21% - 25%] |
| 2010 | 26.8% | [23% - 30%] |
| 2011 | 19.6% | [17% - 22%] |

As observed in this table, colony losses reflected by this survey have significantly dropped between 2008 and 2009 and between 2010 and 2011.

As in the case of other questionnaires, beekeepers were asked to make qualitative evaluations on the state of their apiaries. Following this feedback the report is trying to extract some conclusions on the evolution of certain aspects observed by beekeepers over these four years.

| Aspect | Trend observed over the four years |
|---|---|
| Strength of colonies entering in winter | Improvement from 2008 (18% weak colonies) to 2011 (6% weak colonies) |
| Evaluation of the last honey production | Average to good in 45% of apiaries in 2008, 61, 70 and 85% in 2009, 2010 and 2011 |
| Food stock before feeding | Good in 34% of apiaries in 2008, 44, 52 and 57% in 2009, 2010 and 2011 respectively |
| Treatment of Varroa considered as not effective | 31, 30, 22 and 15% of apiaries in 2008, 2009, 2010 and 2011 respectively |
| Beekeepers certified "AB" (organic treatment of Varroa) | 27% in 2010 and 24% in 2011 |

Statistical analysis identified Varroa treatment strategies and colony strength when going into winter as the two major factors contributing to colony losses. Other factors such as food resources availability, food stock before colony feeding and beekeeping purposes (pollination or honey production) were seen to have had an influence over one or two years of the survey.

In the report issued in 2012, the questionnaire was circulated to all beekeepers independently of the number of colonies owned. A total of 97 beekeepers responded, 79% of which own less than 150 colonies. Overwinter losses were estimated to 20.7%. This number is however not to be compared to the previous years as beekeepers were not selected on the same basis and previous surveys revealed beekeeping practice as a factor contributing to overwinter losses.

Losses of honey bee colonies are monitored in a few European countries through national survey schemes and the involvement of the COLOSS project. Although improvement can be noticed in harmonization in the reporting of losses and of the factors involved, the current feedback displays the diversity of the phenomenon among countries, reflecting the different relative importance of factors and of the solutions to deal with them. Professionalism, colony strength and food resource appear to bear a potential for indicators in honey bee losses, which needs to be confirmed through the on-going monitoring schemes and translated into future research programmes. Improved dissemination of data from these monitoring schemes and feedback to beekeepers may stimulate interest and increase active participation in future monitoring schemes.

### 2.2.4 Colony losses in USA

The winter colony losses in USA were recorded through a survey which was conducted by the Bee Informed Partnership. Over the winter 2010-2011 the total losses in US were 29%. Since 2006 the overwintering losses in USA appear to be high. More specifically the reported losses for the winters 2006-7, 2007-8, 2008-9 and 2009-10 were 32%, 36%, 29% and 34% respectively (vanEngelsdorp *et al.*, 2007, 2008, 2010, 2011a). High rates of overwintering colony losses have been reported in North America, such as in Europe (van Engelsdorp *et al.*, 2008, 2010, 2011a; Currie *et al.*, 2010; Neumann and Carreck, 2010; Nguyen *et al.*, 2010; Potts, 2010).

The reason for the high colony losses in USA cannot be totally interpreted, thus continuous efforts should be made in order to understand the underlying causes of colony losses. Nevertheless the reasons that were more frequently mentioned by the beekeepers were: starvation, weak colonies in the fall; poor wintering conditions; poor queens and Varroa mites. Responders who suspected as responsible for their losses poor wintering conditions, Varroa mites, small hive beetles and/or CCD were proved to have higher average losses than those who suspected other factors.

The average losses between backyard beekeepers (1-50 colonies), sideline (50-500) and commercial (more than 500 colonies) appear to vary between 38.5; 37.4 and 28.3 respectively. Small-size operations experience higher losses than the larger operations. However, larger operations were more likely to report the defining symptom of CCD, the absence of dead bees in the hive of the apiary. Similarly, as reported by COLOSS, in most European countries hobbyist beekeepers experienced higher losses than the intermediate size beekeepers.

## 2.3 Incident Reporting

Systems for reporting and analysing 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. Examples of incident monitoring schemes from several EU countries are outlined below.

It needs to be pointed out that there are many differences between countries in the definition and understanding as well as reporting of incidents. For example in France, it is considered an incident if 10% or 3000 bees are reported dead, while in UK samples submitted by beekeepers are accepted into the scheme on an individual basis based on evidence available. In Germany all samples with a suspected incident may be investigated and count as a reported incident. In some countries one incident includes more than one affected hive while in others each hive reported or sample sent to laboratory is counted separately. Hence a comparison between countries is impossible to make. Further work to harmonize reporting format is on-going within the OECD PEIP group.

### Incidents in France after 2009

Incidents as reported by two authorities in France are presented. The first is Institut Technique et Scientifique de l'Apiculture et de la Pollinisation, ITSAP (Technical and Scientific Institute on Beekeeping and Pollination) and the second is Brigade Nationale des Enquetes Veterinaires (BNEV). The BNEV reported incidents for 2009 and 2010 but is not in charge of investigations on honey bees' incidents anymore. In total 13 incidents where pesticides might be implicated were reported for 2009, 3 for 2010 and 3 for 2011. However the incidents (a total of 7 from ITSAP) are probably quite higher because incidents are reported even for a single colony.

| Year | Number of incidents related to pesticides | Number of colonies in which mortalities were observed | Crop in which the incident was reported | Comment |
|---|---|---|---|---|
| 2009 | 2 | 180 | | The presence of a maize field in the vicinity was suspected as the cause of the incident however no relationship was established |
| | | 80 | Lavender | Suspicion of the treatment of a lavender crop with deltamethrin |
| 2010 | 2 | 80 | Lavender | Suspicion of the treatment of a lavender crop with bifenthrin and endosulfan |
| | | 30 | Maize and sunflower | During a treatment with deltamethrin |
| 2011 | 3 | 40 | Apple trees | Treated with acetamiprid |
| | | 96 | Vineyards and lavender | Treated with indoxacarb and madipropamid. A fast depopulation was observed as well as abnormal behaviour |
| | | 20 | Apple trees | Treated with fluvalinate and fenconazole. A fast depopulation was observed as well as abnormal behaviour. |

*Table 4. Incident reporting in France from 2009 to 2011 according to ITSAP*

Note that the conditions of pesticide applications were not reported. Therefore it is not possible to ascertain that they were used according to recommendations, which is critical as none the these products is expected to cause any problem in honey bees under the recommended conditions of use.

Table 5. Incident reporting in France from 2009 to 2011 according to BNEV

| Year | No. Of incidents reported as "acute intoxication" | Pathology | Pesticide | Bad beekeeping practice | Over-wintering mortality | Destructed by mistake | Disappear-ance of the queen | Appeared not to be an accident | No cause identified |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | 71 | 10 | 11 | 3 | 1 | 1 | 4 | 10 | 31 |
| 2010 | 27 | 3 | 1 | | | | | | 23 |

### Incidents in Germany

In Germany incident samples with suspected bee poisoning incident can be sent to the JKI for further cause analysis free of charge for the beekeeper. Below the number of samples received for analysis, the number of suspected reported incidents, and the number of beekeepers involved are presented.

In general the number of pesticide poisoning incidents explicitly decreased over the last decades. Since 2000 two years with exceptionally high incidents with pesticides occurred 2003 and 2008. After these incidents, due to bee poisoning in potatoes with honeydew in 2003 and due to bee poisoning incidents after insecticidal dust drift during maize sowing in 2008 (data for 2008 include 750 bee keepers damages due to dust drift with approximately 12.000 damaged hives as described in Pistorius *et al.*, 2009) have proven to cause severe damage to colonies, specific risk mitigation measures were adapted and implemented.

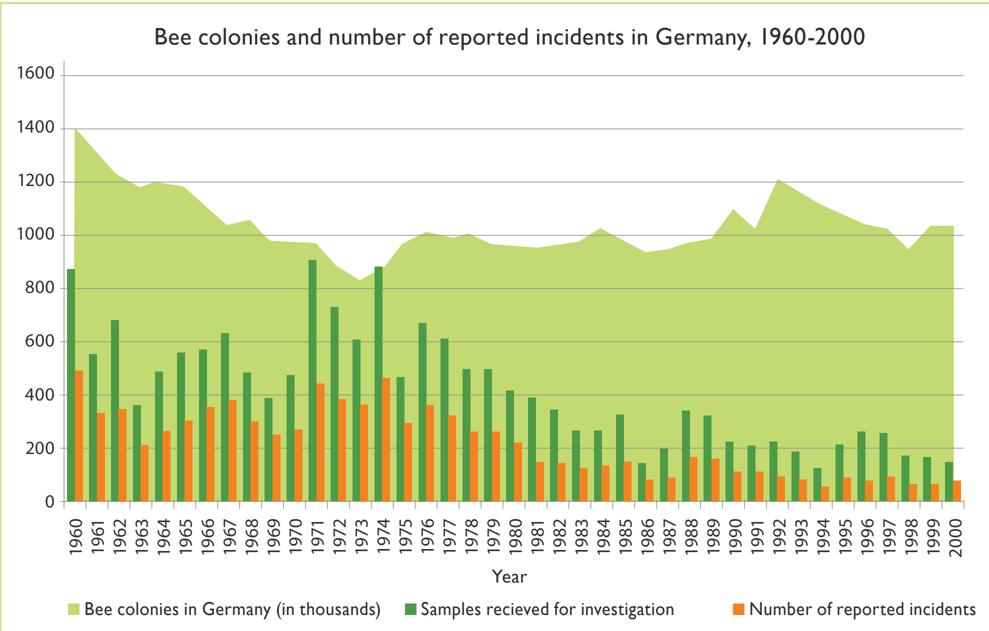


Figure 3: Number of reported incidents 1960-2000

Intensive communication of the Incident investigation scheme in Germany and the possibility to get samples investigated free of charge may also have contributed to the awareness level and the participation rate of beekeepers especially after 2008.

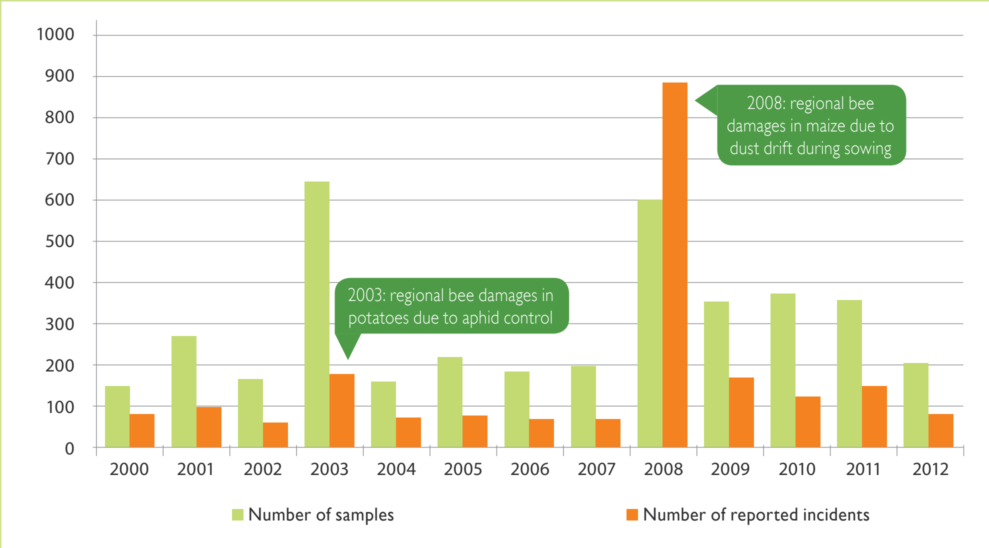


*Figure 4: Number of reported incidents 2000 - 2012*

Nevertheless, as quality and quantity of samples do not in all cases meet the requirements for meaningful analyses, as in some cases potential poisoning can be excluded with a high probability and the bee damage is linked to other causes with a high probability, the number of samples reported is always higher than the number of samples where a potential link to a poisoning incident cannot be excluded and the analyses are possible and may help clarify the incident causality.

The portion of annual incidents that is likely to be related to pesticide poisonings ranges roughly between 40-70% in regular years (Pistorius, pers. com). An example for evaluation is given for 2011 and 2012.

*Table 6. Residues in analyzed samples 2011-2012*

| Residue findings in dead bees | 2011 | 2012 |
|---|---|---|
| bee samples | 101 | 53 |
| n.n. (no Pesticides) | 24 | 7 |
| Traces of untoxic/low toxic pesticides | 23 | 4 |
| bee toxic insecticides | 48 | 34 |
| bee toxic biocides (fraud) | 6 | 6 |
| analyses ongoing | 0 | 4 |

### Incidents in United Kingdom

In Table 7 a summary of the number of incidents is presented while a complete description of incidents and associated information can be found on the Chemicals Regulation Directorate (CRD) website and additional information on the Wildlife Incident Unit (WIUS) of the Food and Environmental Research Agency (FERA).

| YEAR | Incidents Investigated | No of Incidents attributed to Pesticides |
|---|---|---|
| 2002 | 25 | 5 |
| 2003 | 24 | 8 |
| 2004 | 23 | 4 |
| 2005 | 17 | 1 |
| 2006 | 15 | 2 |
| 2007 | 20 | 2 |
| 2008 | 32 | 5 |
| 2009 | 35 | 10 |
| 2010 | 22 | 14 |
| 2011 | 18 | 7 |
| 2012 | 30 | 7* |

*Table 7. A summary of the number of incidents from 2002 onwards*
**This figure may be subject to changes as not all the investigations have been finalized yet.*

### Incidents in Greece in 2011 and 2012

Although no official, systematic reporting system of incidents exists in Greece, 58 samples of honey bees, pollen and honey from individual beekeepers were sent to BPI Toxicology LAB after honey bee death incidents were observed and reported during 2011 and 2012 [59% honey bees (34), 24 % pollen (14), and 17 % honey (10)]. The origin of samples was mainly from Attica and Northern Greece. The number of incidents which might be related to pesticides was 16 for 2011 and 18 for 2012.

Indicatively 73% of honey bees were positive at least to one pesticide (*Kasiotis et al.* unpublished). Pesticides detected were the following: clothianidin, imidacloprid, thiamethoxam, thiacloprid, chlorpyrifos ethyl, indoxacarb, trifloxystrobin, carbendazim, penconazole, fipronil and fipronil sulfone.

The analyses confirmed residues of the above pesticides. Pesticides in general have been suspected for the death incidents of bees, and this was alleged or hypothesized by individuals who sent the samples. However there was no extra information as regards the causality of death, which could also be attributed to pathogenic organisms. Thus the detection of pesticides on its own cannot entirely attribute these incidents to pesticides. For bees indicatively 20 samples contained clothianidin (59 % of all bees samples analyzed), 3 imidacloprid (9%) and 5 chlorpyrifos ethyl (15%).

The evaluation of incident reports shows that numbers of pesticide-related bee incidents are declining in some monitored countries (Germany, France). The variance of incidents in other countries such as UK and Greece is not significant, but in Greece no official monitoring program exists and data occur only after 2009 and more regularly since 2011.

As indicated at the beginning of the chapter a comparison between countries is impossible to make due to the differences in the organization of the reporting system and definitions or rules used to report the incidents.

# CHAPTER 3. BEEKEEPING PRACTICES AND IMPACT ON BEES' WELFARE

To keep and to maintain honey bee colonies successfully knowledge on bee biology, bee keeping techniques, disease biology, and disease treatments and techniques as well as suitable equipment is essential. Permanent efforts are ongoing to perform research on possible improvements and to enhance knowledge communication and knowledge transfer.

Improvements of bee keeping techniques and new bee keeping equipment in the beekeepers apiary enable improved bee health, more gentle and easier handling, easier transport, improved quality and quantity of bee products, facilitation especially of honey harvesting, easier counting and treatment of Varroa mites.

### 3.1.1 Hive systems

Historically, *Apis mellifera* colonies lived in cavities e.g. rock cavities and in hollow trees before first hive systems were introduced and improved. This has enabled honey harvesting without having to hurt or kill the colonies and to domesticate and attend colonies.

Supplied housing materials evolved from containers where the bees built their combs freely (e.g. hollow trees and Skeps) to modern bee hives with moveable frames, which allow a gentle honey harvesting without disturbing or harming bees. Whereas in many poorer countries bee keeping is still practiced in very simple forms, e.g. mud hives, in most countries bee hives with frames are used. While stationary beekeeping has historically often been practiced in many different countries, the general trend in Europe is to use mobile hive systems, which allow migratory beekeeping to enhance honey yield, conduct pollination services and may facilitate bee keeping practices and disease treatments.

Depending on the hive system used, modern systems may have significant improvements compared to older hive systems. As properly maintained hive and honey extracting material may be used for a decade or so, changing to new hive systems may not always be very rapid, and for some stationary apiaries (e.g. bee houses) it may not easily be possible to adapt to new hive systems at all without major change. Hive systems may be of various sizes and constructed by different materials; the number of combs in a hive and the frame sizes vary greatly.

As hive system, Langstroth is the most used hive in America, Europe, Asia, Australia, and Northern and Southern Africa. Nevertheless, also within continents, even within countries, there is a huge number of different hive systems and frame sizes, e.g in UK the National Hive is considered to be the most popular hive system, in Germany Deutsch-Normal, Zander and Dadant.

Whereas frame size is of very low significance, the construction of the hive is of high importance for the well-being of bees. Some adaptions of bee keeping and also disease treatment practices may be necessary with different hive systems and equipment used. The diversity of different hive system complicates the provision of general recommendations for bee keeping and especially Varroa treatment procedures, as minor modifications may provoke a major difference in effectiveness, and fortifies the need for further research and enforced advisory service.

### 3.1.2 Bee colony management

The techniques for keeping bees have evolved rapidly in the last decades. Bee keeping requires numerous different work steps which depend upon the season, the colony status, the available forage, the disease status and the bee subspecies. Bee keeping activities include e.g. supplying space, frames and food to bees at the right times, specific actions like swarm prevention measures, queen and nucleus production, honey production and harvesting, parasite and disease treatments, hive hygiene, comb renewal and overwintering preparations.

Successful bee keeping requires the ability to detect the need for specific actions with the colonies and to conduct the necessary measures. In principle, there are many different ways to keep and manage bees throughout the year and how to conduct the necessary measures. Different programs are conducted in many nations worldwide to promote the state of knowledge and to provide guidance on beekeeping practice adapted to the local needs.

The majority of bee keepers in many western countries are hobby bee keepers, e.g. in Germany 1–20 colonies are kept by 80 % of bee keepers, 21–50 colonies by 18 % of bee keepers and more than 50 colonies by about 2 % of bee keepers.

In an attempt to survey the different beekeeping practices across the continent, de la Rua et al., 2009 consulted research institutions, beekeeping organizations, published reports and open access data bases, gathering beekeeping statistics on 33 European countries.

As an example for national research activities, the 'FIT BEE' Project is a collaborative project in Germany addressing interactions and correlations between single bees, bee colonies, bee diseases and environmental factors. In order to explore the vitality of bees, several topics are treated within several modules. The healthy, vital bee colony ('FIT BEE') is the central focus of the project. The project's component modules aim - within the context of an integrated network - at understanding more deeply the complex interactions between the individual bee, the bee colony, bee diseases and environmental parameters. The project thereby aims to define conditions for a healthy bee colony and to improve them by Evaluation of parameters to describe the vitality of bee colonies, investigation of multifactorial influences on the vitality of individual bees and on the bee colony, Investigation of bee diseases, studies on the significance of agricultural production methods (Fitbee, 2012)

Other projects, like the BIV (Betriebsweisen im Vergleich) - Project tests management techniques that help ensure excellent honey yields and effective control of *Varroa destructor,* which thus help to reduce winter losses significantly (Aumeier *et al*., 2010). Different operational methods with different hive systems and different bee keepers measures for colony renewal, queen- and nuclei production, Varroa treatments and overwintering preparations are tested and development of colony strength, overwintering success and disease infestation frequently assessed.

Policy makers need to be aware of the high importance of such research activities for the bee keeping sector and the need for further increased efforts on gathering results on the national and international level and communication of knowledge.

# CHAPTHER 4. THREATS TO BEE HEALTH

There is insufficient knowledge of causative and risk factors associated with colony losses; declines are not only unmeasured in many parts of Europe, but also often unexplained.

There are a number of factors which can impact upon the health of honey bees including; pests and disease, pesticides, beekeeping practice, agricultural practice and climate. These factors do not act upon the colony individually, but involve complex interactions.

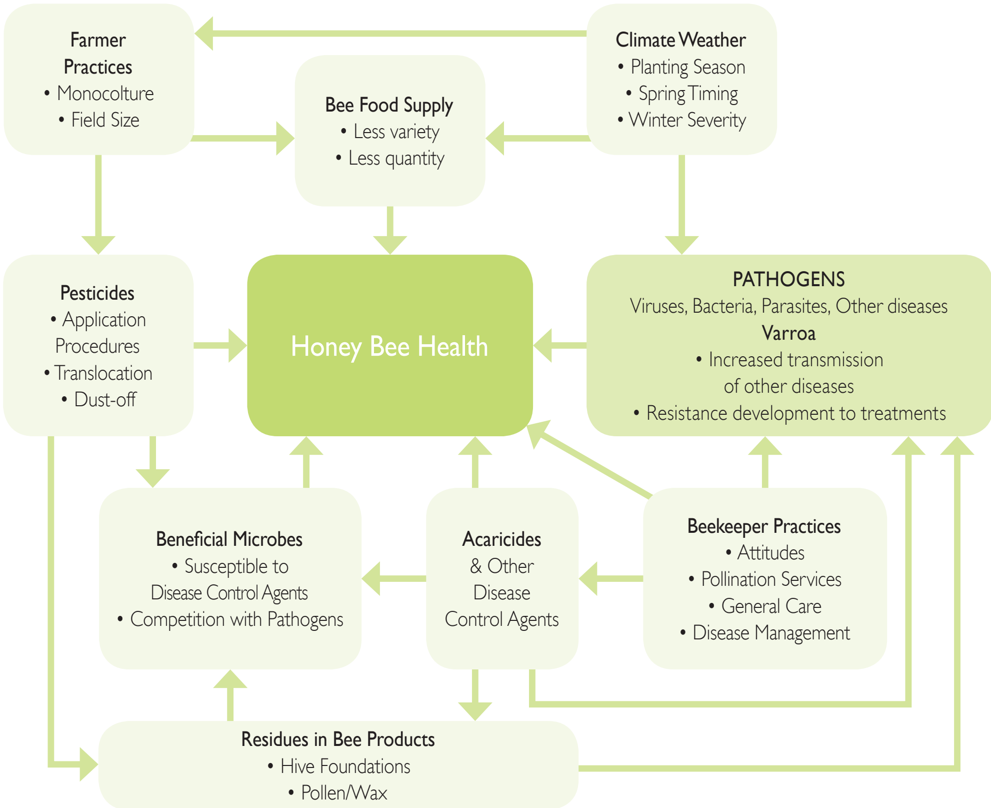


*Figure 6. Interrelationship of bee health Stressors Adapted from Le Conte **et al.**, 2010,*

## 4.1 Pests and diseases: evaluating the threat

There are a wide number of pests and diseases to which honey bees are susceptible. It is not intended to describe all of these here but to cover those which have been demonstrated as being implicated with colony losses as described by EFSA (2009) and Genersch (2010). These suggest that the major pests/diseases are *Varroa destructor*, American foulbrood, European foulbrood, *Nosema* spp., honey bee viruses,, and Acarine mite *(Acarapis woodi)*– these will be covered here. This enumeration is proposing an order of perceived significance of the pests and diseases, however, this may actually depend upon many interacting factors and the relative importance of a pest or disease may change under different circumstances.

In the past introduced parasites such as the Varroa mite have been particularly devastating to honey bees, therefore future threats and non-native invasive species are also discussed here; Small Hive Beetle *(Aethina tumida), Tropilaelaps sp.* and the Asian Hornet *(Vespa velutina).*

CCD (Colony Colapse Disorder) is a well-defined syndrome (see for instance van Engelsdorp et al., 2009, 2010) that seems to be limited to US; it will not be covered here as it does not appear to occur within Europe. Although there has been a single reported incident (Dainat *et al.*, 2012), such symptoms have not been seen regularly or reported across Europe and the phenomenon is clearly not the same as that reported in the USA (Detailed information of the current status in the US may be found at https://agdev.anr.udel.edu/maarec/category/ccd/).

The symptoms of CCD as described in the US, based on the available research, include the following:

- rapid loss of adult worker bees,
- few or no dead bees found in the hive,
- presence of immature bees (brood),
- small cluster of bees with live queen present, and
- pollen and honey stores in hive.

| | | Factor Listed | | Not Listing Factor | Kruskal Wallis Rank Sum Test | |
|---|---|---|---|---|---|---|
| Factor | n | Avg Loss % (95%CI) | n | Avg Loss % (95%CI) | $x^2$ | p |
| Starvation | 1053 | 53.7 (51.8-55.7) | 1629 | 54.4 (52.8-56.0) | 0.16 | 0.6822 |
| Weak in the fall | 921 | 52.8 (50.7-54.9) | 1761 | 54.8 (53.3-56.4) | 1.78 | 0.1840 |
| Poor winter | 833 | 64.3 (62.2-66.5) | 1849 | 49.7 (49.1-51.0) | 118.8 | 0.0001 |
| Queen | 655 | 47.5 (45.0-50.0) | 2027 | 54.4 (52.8-56.0) | 37.5 | 0.0001 |
| Varroa | 534 | 59.5 (56.8-62.3) | 2148 | 52.8 (51.4-54.2) | 18.8 | 0.0001 |
| Nosema | 317 | 55.9 (52.3-59.5) | 2365 | 53.9 (52.6-55.3) | 1.14 | 0.2843 |
| CCD | 199 | 65.1 (60.6-69.6) | 2483 | 53.3 (52.0-54.5) | 23.6 | 0.0001 |
| Pesticides | 125 | 58.9 (53.1-64.6) | 2557 | 53.9 (52.7-55.2) | 2.51 | 0.1134 |
| Small hive beetle | 96 | 63.7 (57.1-70.2) | 2586 | 53.8 (52.5-55.0) | 8.29 | 0.0040 |

*Table 8. Average Losses reported by Beekeepers in the US who listed one or more factors as the leading cause of mortality 2010-11 (van Engelsdorp et al., 2012)*

### 4.1.1 Established Threats

#### 4.1.1.1 Varroa mite

*Varroa destructor* is a parasitic mite of honey bees, capable of devastating infested bee colonies and in fact it has been described as the single greatest challenge posed to beekeeping worldwide. The native host of *V. destructor* is the Asian honeybee *(Apis cerana),* however, the mite has crossed the species barrier and can reproduce highly efficiently in colonies of *Apis mellifera* the Western (or European) honey bee. This mite 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 the developing bee larvae.

The adult female mites commonly seen within the hive and on the bees have flat, reddish-brown oval bodies, greater in width than length (1.6 x 1.1mm). The Western honeybee has no or limited natural defences to the Varroa mite.

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. In the absence of control, colonies normally die within 3-4 years (Martin *et al.*, 1998) with a decline in the adult bee population until only a few bees and the queen remains. The mite is also a vector of a number of viruses and 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. There is a strong link with the presence of DWV, SPV or CWV and Varroa.

Varroa mites are mobile and move between bees and within the hive. However, to move from colony to colony they are transported by the adult bees and through the natural processes of drifting, robbing, and swarming. Varroa can spread slowly over long distances in this way. However, long distance movement of infested colonies has been responsible for the mite infesting new areas. Today mites can be found in almost every apiary in Europe and the mite has spread to all continents where honey bees are managed with the exception of Australia.

There are a range of treatments for Varroa although their efficacy varies widely and there is no "magic bullet". The current situation regarding Varroa treatments in Europe can be seen on the UK Veterinary Medicines Directorate Website (VMD) (http://www.vmd.defra.gov.uk/fsf/bee_europe.aspx) and on "The Heads of Medicines Agencies" website (http://www.hma.eu/uploads/media/136_Questionnaire_-_Bee_products_in_EU_24.10.11_EMA-CMDv-36668-2009.pdf) When Varroa was first detected in Europe treatments such as Apistan™ (tau-fluvalinate) and Bayvarol™ (flumethrin) were used and were highly effective. More recently amitraz (Apivar™) and coumaphos (Perizin™) have been used but resistance is also developing (Mathieu et Faucon, 2000) or already established and beekeepers are resorting to more labour intensive and usually less effective products in Integrated Pest Management (IPM) type approaches. For example, essential oils such as thymol have been used and continue to be used for Varroa control and organic acids such as lactic acid, formic acid and oxalic acid are used routinely to control the mite.

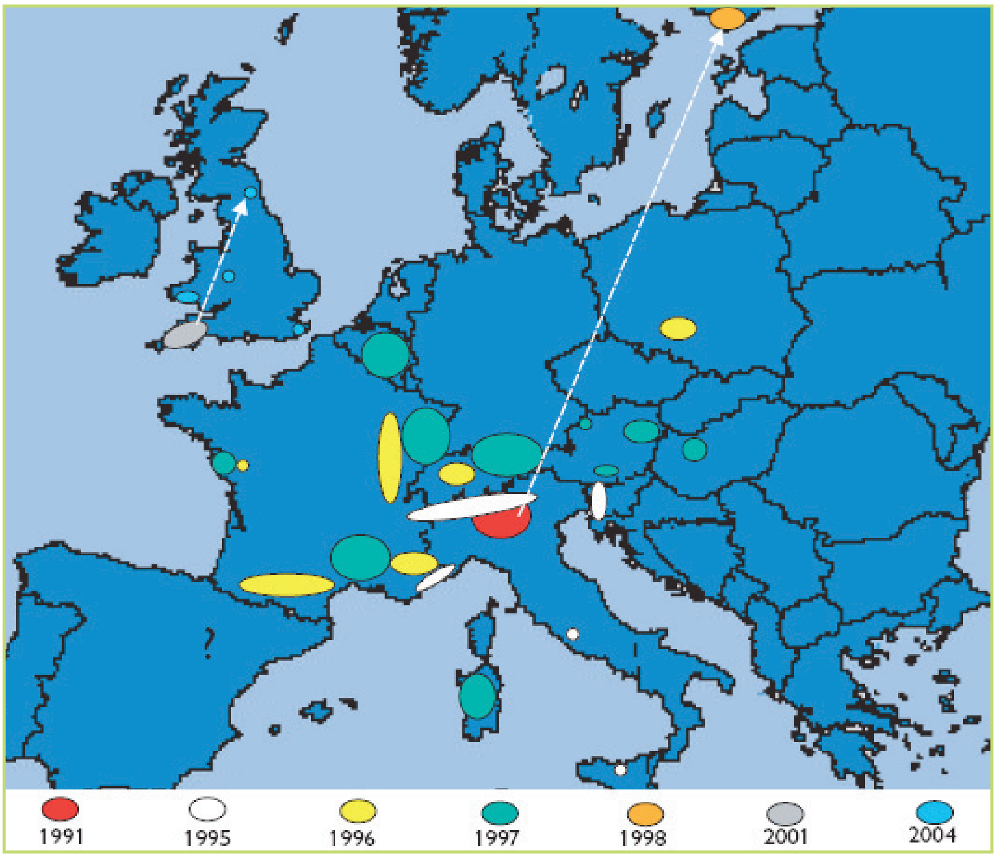


*Figure 7. Spread of Varroa resistance to synthetic pyrethroids tau-fluvalinate (Apistan™) and flumethrin (Bayvarol™)*

A recent study carried out in Hawaii by Martin *et al.*, (2012) showed that after introduction to the island state in 2007 the Varroa mite increased the prevalence of a single viral species, deformed wing virus (DWV), from ~10 to 100% within honey bee populations.

Unexpectedly the same study also showed that the presence of Varroa on Hawaii however, did not affect the prevalence of the honeybee pathogens KBV, IAPV or APV. These three viruses have long being associated with Varroa associated colony collapse. However, they naturally occur at a higher prevalence than DWV in healthy colonies that have never being infested by Varroa. So in honeybee studies where DWV and any of these three viruses co-occur the effects of each pathogen needs to be separated out.

The most important finding of the Hawaiian study was that Varroa has irreversibly changed the DWV viral landscape across the world. That is, over a period of years the Varroa-honeybee transmission cycle has selected for a cloud of DWV strains that are able to replicate to very high levels in honeybees, which in colonies where the Varroa populations are not controlled will lead to colony collapse. However, even when Varroa levels are controlled DWV now persists in the honeybee population at very high (almost 100% prevalence) levels and there is some evidence that it may be responsible for the increased overwintering colony losses reported by COLOSS (Highfield *et al.*, 2009), and could potentially play a role in CCD if a particular virulent cloud of variants emerged (Schroeder & Martin, 2012).

In a recent article (Schroeder & Martin, 2012), the author explains that DWV is now the most likely candidate responsible for the majority of the colony losses that have occurred across the world during the past 50 years.

*Image 1. Varroa mites on an adult worker bee*

### 4.1.1.2 Bacterial brood diseases

There are two major bacterial infections affecting honey bee colonies; American foulbrood (AFB) caused by *Paenibacillus larvae* and European foulbrood (EFB) caused by *Melissococcus plutonius.*

*American foulbrood*

American foulbrood is caused by the Gram-positive spore forming bacterium *Paenibacillus larvae*. Larvae become infected by consuming the spores in food which then germinate in the mid-gut, invading the tissues and killing the larvae, usually after pupation.

The characteristic disease signs of AFB include some or all of the following:

- Uneven or 'Pepper-pot' brood pattern
- Sunken, greasy or perforated, darkened cell cappings
- Roping, sticky larval remains when drawn out with a matchstick (See Image 2)
- Dark "scales", which are difficult to remove from cells (see image 3)

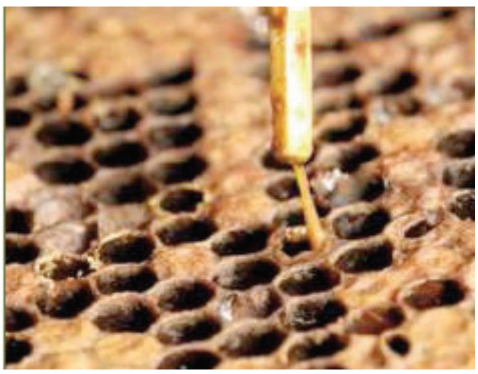

*Image 2.Clinical signs of AFB: Rope*
*Image 3. Clinical signs of AFB: Scale*
*Photographs courtesy of Fera National Bee Unit*

The spores are resistant to heat and cold and to disinfectants and are viable for many years in honey, old combs or derelict hives. Once a colony is infected with AFB the disease will usually progress until the colony dies. AFB cannot be eradicated with antibiotics as they act as bacteriostats (i.e. agents that stop bacteria from reproducing without killing them), and these do not affect the spores either which are the primary mode of transmission within the hive. Antibiotics are widely used outside Europe and there is strong evidence of the development of resistance to antibiotics in *P. larvae*, e.g. oxytetracycline in the USA (Murray 2009). AFB is a notifiable disease throughout Europe and the only method of control in Europe is destruction of infected colonies.

Robbing by adult bees of contaminated honey sources, including weakened, dying dead or infected colonies is an important mode of transmission between colonies. However, transmission from infected hives to healthy hives due to beekeeper practice is also a serious risk. By bringing in infected colonies or contaminated used material from other apiaries spore contamination may be transferred to the apiary. Spores can easily be transferred between hives directly, if contaminated frames of honey or brood are moved between hives, or if other contaminated equipment is used. If left to run its course, all colonies infected with AFB will eventually die from the disease.

*European foulbrood*

The causative organism of European foulbrood is the non spore forming Gram-positive bacterium *Melissococcus plutonius*. Larvae become infected by ingesting contaminated food and the bacteria multiply within the midgut of the infected larvae competing with the larva for food. Infected larvae usually die prior to cell capping due to starvation rather than invasion of the body tissues by the bacterium in some cases larvae may die after capping, sometimes the larvae survive to pupation, producing undersized adults.

The characteristic signs of EFB may include:

- Erratic or uneven brood pattern
- Twisted larvae with creamy-white guts visible through the body wall
- Melted down, yellowy white larvae
- An unpleasant sour odour
- Loosely-attached brown scales

As with AFB the beekeeper is a key method of transmission, if brood combs or other items are transferred from an infected hive to a healthy hive. However, robbing of weakened infected colonies and swarms are also means of spread.

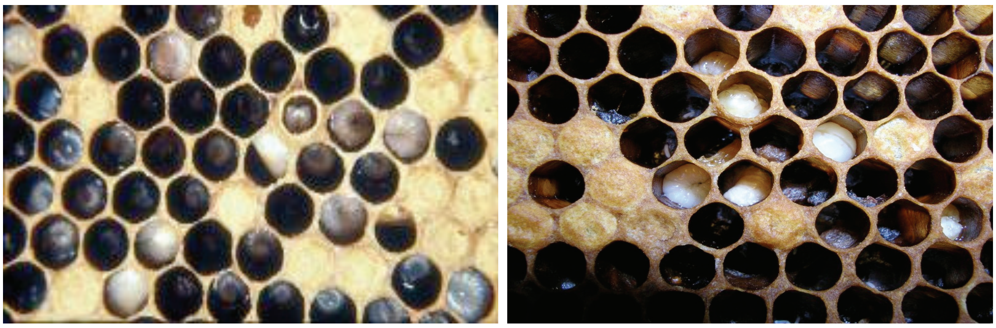

*Image 4. Clinical signs of EFB*
*Photographs: Fera National Bee Unit*

European foulbrood (EFB) is well distributed across every continent that honey bees inhabit (Matheson 1993) and in many cases has not been considered a problem for apiculture. However, it appears to have increased in importance more recently, particularly for example in the UK (1002 cases in 2012 - figures available on National Bee Unit website nationalbeeunit.com), Switzerland (cases increasing 10 fold in 10 years (Roetschi *et al.*, 2008) with 796 outbreaks in 2009 (Genersch 2010) and more recently in Norway. In Norway EFB was first reported in 2009 and in winter 2011 (1250 cases in 2011) an eradication campaign was instigated, costing an estimated 1.5M€ in compensation (Sorum *et al.*, 2012 (York COLOSS meeting)).

The status of EFB varies across Europe, being a notifiable disease (i.e. its suspected presence must be reported to the relevant authorities) in some Member states, (e.g. UK and Switzerland) and not in others (e.g. The Netherlands). The treatment of EFB also varies across Europe, ranging from destruction or shook swarm (destroying the infected combs and shaking the bees onto clean foundation and boxes) or by feeding the colony with the antibiotic oxytetracycline (OTC) (Coloss Foulbrood survey- unpublished).

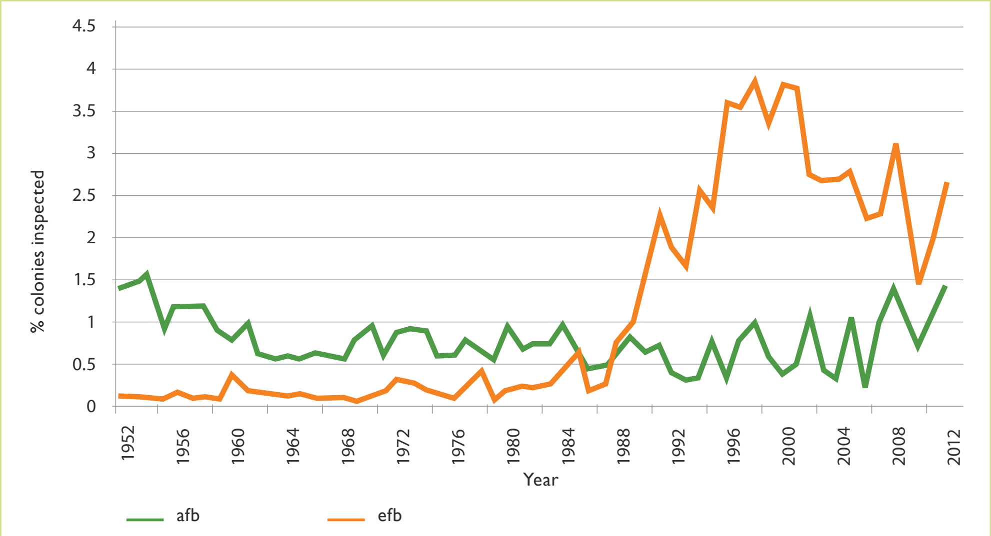


*Figure 8. Annual occurrence of EFB and AFB in England, Wales and Scotland (From NBU BeeBase Database)*

### 4.1.1.3 Nosema spp

There are two species of the microsporidian (fungus) Nosema associated with clinical signs of disease in honeybees: *Nosema apis* and *Nosema ceranae*. *Nosema* spp. invade the digestive cells lining the mid-gut of the bee. Here, they multiply rapidly and within a few days the cells are packed with spores. Nosema spores are transmitted by a variety of routes including honey, pollen (including corbicular loads from bees (Higes *et al.*, 2008)), wax, royal jelly and even in regurgitated pellets of the European bee-eater *(Merops apiaster)* (Higes *et al.*, 2008a).

*Nosema apis* has been the species traditionally associated with honey bees, first described over 100 years ago. Nosema ceranae is a more recent transfer from the Asian honeybee Apis cerana first reported in Europe in 2005, (Higes *et al.*, 2006; Antunez *et al.*, 2009, Botias *et al.*, 2012a). *N. ceranae* was confirmed in many European countries including Denmark, Finland, France, Germany, Greece, Italy, Serbia, Spain, Sweden and Switzerland (Paxton *et al.*, 2007) and in the UK in 2007 (Budge, 2008). Mixed infections are common (Forsgren and Fries, 2010). In a recent study carried out in Spain *N. ceranae* was the most commonly identified pathogen, found in 70% of samples screened (Higes *et al.*, 2010).

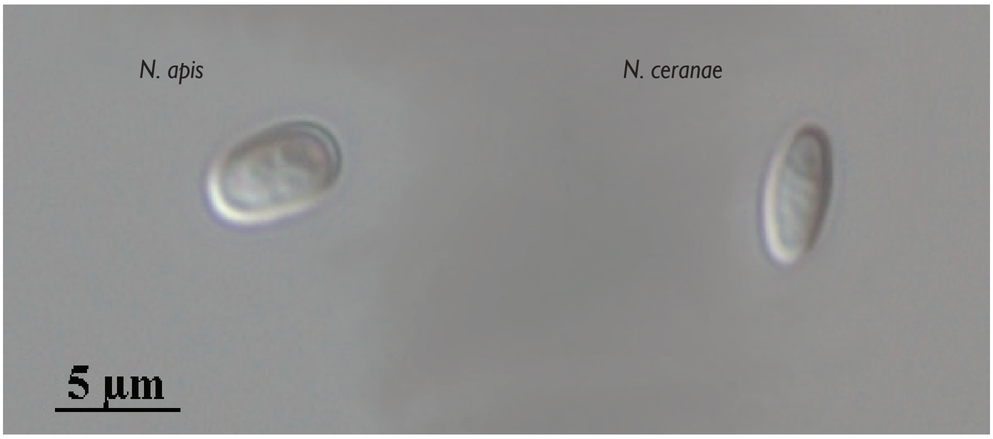


*Image 4. Spores of N. apis and N. ceranae Photograph courtesy of Fera National Bee Unit*

*Nosema apis* is currently more prevalent in cooler climates (Fries 2010) and primarily affects honey bees in the spring and early summer. It has been referred to as "Spring dwindling", often seen in combination with dysentery and fouling of the outside of hives with faeces. Infected bees will age more quickly, taking on the roles of older bees, subsequently these infected bees will die sooner than uninfected individuals.

*Nosema ceranae* does not show this seasonality (Martín-Hernández *et al*., 2007) and there is also an absence of classical signs of *Nosemosis* in colonies. *N. ceranae* is more stable at warmer temperatures (Fenoy *et al*., 2009) and appears to be more virulent than *N apis,* causing colony deaths in warmer drier climates. This may explain why *N. ceranae* has been attributed to high colony losses in Southern Europe, particularly Spain, Greece, Italy and Portugal and anecdotally does not seem to be a major problem in Northern Europe. A study carried out by Dussaubat *et al.,* (2012) looking at strains of *N. ceranae* from Northern Europe (France) and Southern Europe (Spain) showed no differences in virulence of strains and it was considered that the response of the strain of honeybee to infection may be more critical, e.g. increased susceptibility of *A mellifera iberiensis.*

The only treatment for *Nosema* has been fumagillin (an antimicrobial agent isolated from *Aspergillus fumigatus*) but this is not registered across Europe and methods of application for treatment of *N. apis* may not be as effective for treatment of *N. ceranae* (Higes *et al.,* 2011). Work carried out in Spain by Pajuoelo *et al*., (2008) suggested that if the effects of stressors such as high levels of Varroa, poor management, climate or poor nutrition (all causes of immunosuppression) were managed then colonies did not collapse in the presence of *N. ceranae*. But more recently, Higes *et al.* (2013), described in detail the clinical signs associated with the disease caused by *N. ceranae* and they give the keys to understand this disease and prevent the frequent errors of interpretation occurring in field and laboratory studies.

#### 4.1.1.4 Viruses

There are a large number of viruses associated with honeybees (at least 18) but until the introduction of Varroa they were generally considered harmless (Genersch and Aubert 2010). It appears that Varroa acts as both a disseminator and activator of a number of viruses including the Dicistroviridae (acute bee paralysis virus (ABPV), Kashmir bee virus (KBV) and Israeli acute paralysis virus (IAPV)). Deformed wing virus (DWV) is a member of the Iflaviridae family and appears not only to be vectored by Varroa but also to replicate within the mite (Genersch and Aubert 2010).

Deformed wing virus is well named as heavily infected emerging bees have atrophied or deformed wings.

*Image 5. Adult bee showing signs of Deformed wing Virus*

DWV is considered to be the most widespread bee virus in Europe.

DWV is now considered one of the key players in colony losses in Europe. With the advent of improved molecular techniques the detection of multiple viruses in samples has become more practical and with this an improved understanding of the true distribution of these viruses.

Chronic bee paralysis virus (CBPV) is one of the few viral diseases of adult honeybees with well defined clinical signs (large numbers of paralysed or trembling bees which are black and shiny/hairless) and a dose response (at least in the laboratory). Bad weather with consequent confinement of the bees results in crowding and abrasion of the cuticle as well as transmission via faeces (Ribiere *et al.,* 2007) and thus transmission of the virus.

ABPV displays similar signs to CBPV but on a shorter timescale, the virus has shown to have a geographical distribution similar to that of *A. mellifera* (Genersch and Aubert 2010).

KBV and IAPV are closely related members of the Dicistroviridae family to which ABPV belongs. KBV is prevalent in North America and New Zealand but rarely found in Europe although it has been detected in the UK and Spain (Ward *et al*., 2007). KBV has been identified as being a severe threat to bee colonies in association with Varroa and IAPV awareness was raised when it was reported as the cause of CCD but this has been downplayed recently and is also rarely reported in Europe.

BQCV kills brood in queen cells with clinical signs in the early stages that are similar to sacbrood virus (SBV) which as the name suggests are a sac like appearance of the diseased larvae. Both BQCV and SBV are common and widespread in Europe. BQCV appears to be intimately associated with *Nosema apis* with no infection in the absence of *N. apis* spores although its transmission appears to be related to Varroa infestation. It has been estimated that BQCV is the second most common virus after DWV in Europe.

*Image 6. Sacbrood affected larva*

Cloudy wing virus (CWV) infected bees show loss of transparency of their wings. It is widespread in Europe and appears to be more prevalent in Varroa infested colonies although it is independent of mite infestation levels and does not appear to be routinely associated with colony collapse (Ribiere *et al.,* 2007).

### 4.1.1.5 Acarine Mites

Acarine disease (Acarapsisosis) is caused by the mite *Acarapis woodi* which infests the trachea of adult honey bees. The mite was described in 1921 by Rennie and was tentatively identified as the causative organism of Isle of Wight disease. First detected in the UK in 1904 spreading to the mainland and was later responsible for the decimation of the UK honey bee population in the 1920s.

Female mites enter the anterior thoracic spiracles of young bees and lay eggs in the trachea. Once hatched, the larvae feed on the haemolymph of the bee. The larvae undergo several moults before reaching their adult forms, and are then ready to infest new hosts. Infestation of adult bees with significant numbers of tracheal mites results in high level of bee mortality and poor overwinter survival. Heavily infected bees may show symptoms such as disorientation, climbing grass stems and inability to fly. The mite has also been identified as a vector of viruses (Garrido Bailon *et al.*, 2012).

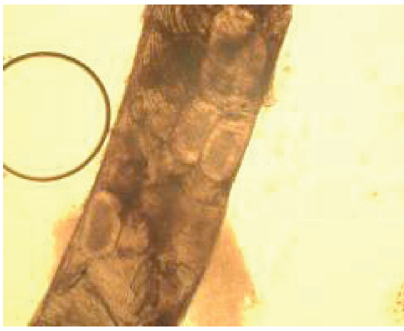
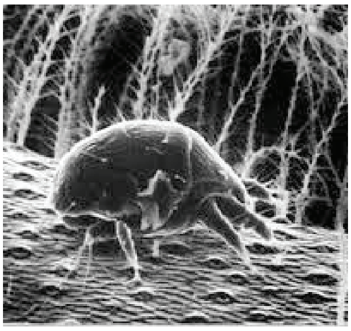

*Image 7. Acarapis woodi: eggs and larvae in an infested trachea*
*Image 8. Acarapis woodi: adult tracheal mite*

There are currently no approved treatments for acarine disease. One of the options available to the beekeeper is to re-queen colonies that are susceptible to the disease. Low levels of acarine disease in countries with previously high incidence such as Spain and France may be due to the widespread use of miticides to counter Varroa. There also appears to be climatic differences with higher incidences in cooler areas and at cooler times of year (Garrido Bailon, 2012). Generally the mite does not seem to be a major cause for concern within Europe, but in North American beekeepers lost many thousands of colonies following the discovery of the mite there in 1984 (Delfinado-Baker). There does appear to be some differences in sensitivity between some honey bee strains.

## 4.1.2 Potential threats to bee health in Europe

### 4.1.2.1 Small Hive Beetle

The Small hive beetle (SHB), *Aethina tumida,* is an invasive species originating from Africa which has proved to be a serious pest of honeybee hives in North America and Australia. The SHB is a statutory notifiable pest within the European Community (Commission Decision 2003/881/EC).

The SHB is native to sub-Saharan Africa. In its native range it is considered a minor pest of weak honeybee colonies and stored honey supers. However, Western honeybees have fewer natural defences against SHB and consequently it has had a far greater harmful consequences when introduced to areas where these are the managed bee species. It was confirmed for the first time outside Africa in Florida USA, in May 1998, and since then has become widespread across the USA. The beetle was later detected in New South Wales and Queensland in Australia in October 2002 and more recently in Canada. The beetle is also present in Mexico, Jamaica Hawaii and in 2012 its presence was confirmed in Cuba.

*Image 9. Small Hive Beetle adult and larvae*

The beetle generally lives and breeds inside bee colonies where developing bees are its primary food source, but it can also survive and reproduce on stored comb and beekeeping equipment, or certain types of fruit, particularly melons. The beetles can multiply to huge numbers. Their larvae tunnel through comb to eat brood, ruin stored honey, and ultimately destroy infested colonies or cause them to abscond. Mature larvae crawl out of the hive to pupate. Pupation usually occurs in soil outside the hive at a depth of around 10 cm and usually within 20 m of the hive. Typically adult beetles usually emerge after 3-4 weeks but emergence can occur anytime between 8 and 84 days post pupation depending on temperature. Adults are able to fly at least 10 km to infest new colonies. Spread is by a number of means; dispersion of adult beetles, by movement of package bees or honey bee colonies, honey bee swarms, honeycomb, beeswax, beekeeping equipment, soil and fruit. Control measures include the use of pesticides within the hive and as drenches on the surrounding soil, together with improved bee husbandry and changes to honey handling procedures in equipment storage and extraction rooms.

Experience in North America and Australia has shown that once established SHB cannot be eradicated. The best form of cure is prevention. However, early detection of an outbreak would be key to managing the spread of the pest. In the UK a 'Sentinel Apiary' monitoring system has been set up in areas of high risk and contingency plans put in place to facilitate management of the problem should an incursion occur.

#### 4.1.2.2 *Tropilaelaps* sp

*Tropilaelaps* mites are parasitic mites affecting both developing brood and adult honey bees. Parasitisation by these mites can cause abnormal brood development, death of both brood and bees, leading to colony decline and collapse, and may result in bees absconding from their infested hive. The natural host of the mite is the giant Asian honey bee, *Apis dorsata*, but *Tropilaelaps* can readily infest colonies of *A. mellifera.*

Currently four species of *Tropilaelaps* mites have been identified. Of these only two (*T. clareae* and *T. mercedesae*) are considered serious mite threats to the Western honey bee *A. mellifera* (Anderson and Morgan, 2007). *T. clareae* is already an economically important pest throughout Asia and the relatively newly characterised *T. mercedesae* has been identified on *A. mellifera* in regions well outside its native range.

The females of *T. clareae* are light-reddish brown and about 1.0 mm long x 0.6 mm wide, and the males are almost as large as the females. The life cycle and parasitism of *A. mellifera* is similar to that of *Varroa destructor. T. clareae* readily infests colonies of *A. mellifera* in Asia, particularly where colonies produce brood continuously.

*Image 10. Tropilaelaps clareae*

Many of the same acaricides used to control Varroa are likely to be effective against *Tropilaelaps*. Although currently there are no products specifically approved for the control of *Tropilaelaps* in Europe, in the event of the mite being discovered, contingency plans would be implemented and emergency approvals sought to use varroacides against *Tropilaealaps*. With the current trends in climate change and globalisation it is highly likely that these species will extend their range in the coming years and should be considered as serious potential threats to European beekeeping.

Over the past 40 years the geographical distribution of *Tropilalaelaps* has spread significantly. The main factor currently limiting survival and spread is their dependency on a continuous, year-round food supply of immature bees within infected colonies, unlike Varroa adult *Tropilaelaps* mites are unable to survive on adult bees for extended periods (as their softer mouthparts are unable to pierce the host's cuticle, preventing feeding). Thus this exotic  mite is more of a potential threat in Southern Europe.

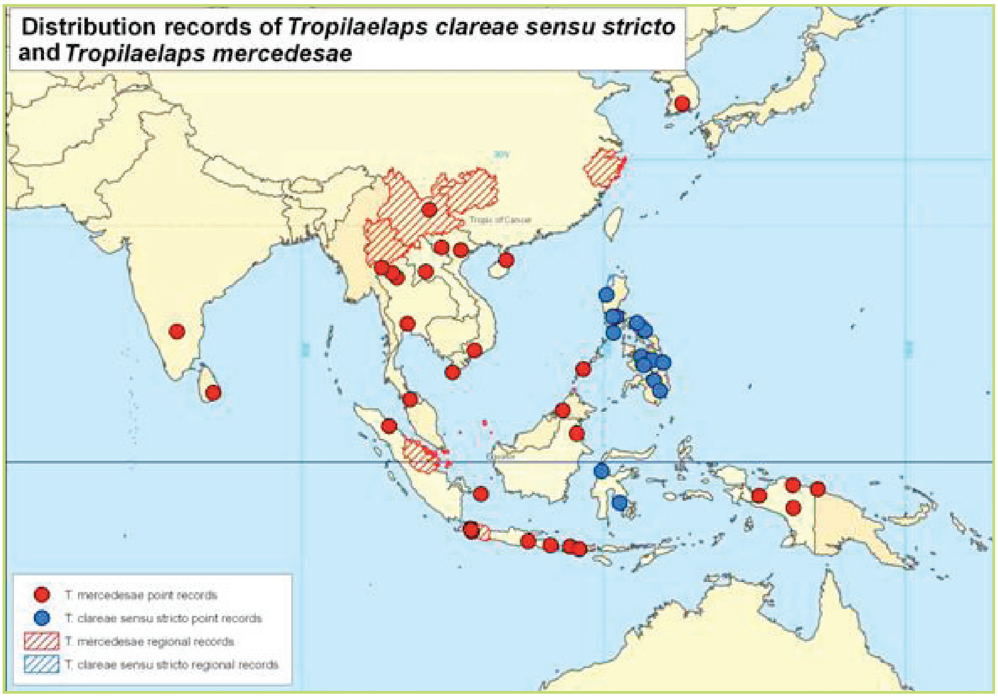


*Figure 9. Distribution of Tropilaelaps sp*

Currently both *A. tumida* and *Tropilaelaps* sp are believed to be absent from Europe (SHB larvae were intercepted in a consignment of 122 queen cages from the USA (Murilhas, 2005)). Introduction of either species would have the potential to cause major damage in certain parts of Europe. Both parasites are statutorily notifiable under EU legislation.

#### 4.1.2.3 Asian hornet

The Asian hornet, *Vespa velutina nigrithorax*, is an aggressive predator of honey bees and other beneficial insects. The adult hornets predate adult honey bees on the wing, taking out large numbers, often attacking in large numbers, they will also enter hives to raid colony. These attacks cause colony stress and a decline by attrition and there are reports of entire colonies being lost due to predation.

It has recently extended its geographical range from Asia to mainland Europe following an accidental introduction to France. It was confirmed for the first time in Lot-et-Garonne in the South West in 2005, thought to have been imported in a consignment of pottery from China. It quickly established and has spread very quickly into many areas of France where it has been reported as causing many problems for both beekeepers and biodiversity in the country.

Adult hornets are highly mobile; the rate of spread across France is approximately 100 km/year. There is now great concern that this exotic insect will reach the other parts of Europe, either by hitching a ride on goods or simply by the dispersion of flying mated queens. The hornet can predate on colonies, causing significant harm. All beekeepers should be on the lookout for this hornet.

*Image 11. Adult Asian Hornet*

It would appear that the hornet is expanding its range and recently the arrival of the hornet was noted in Belgium October 2011, it is not clear if this was an incidental import or if the distribution range expanded northward and also in Portugal in September 2011 (confirmed 2012) and has been found at more than one apiary in the Minho region . The hornet has also been reported in the Guizpuzcoa and Navarra provinces of Spain (Lopez *et al.*, 2011).

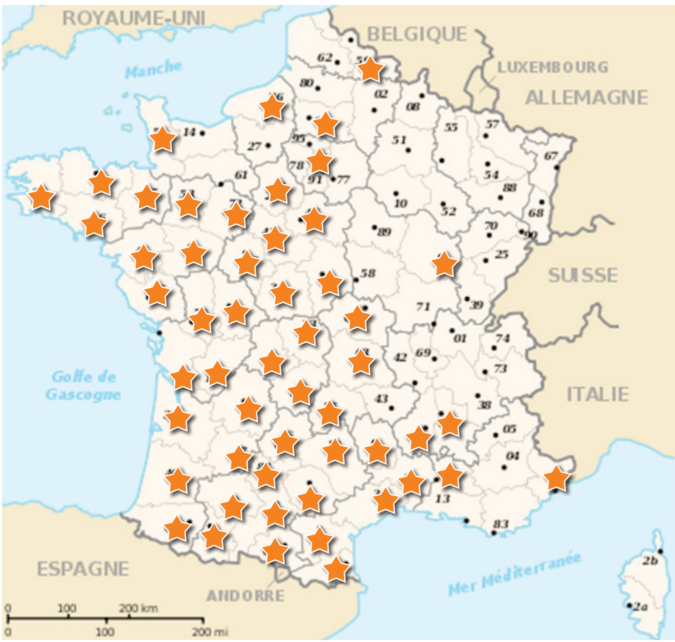


*Figure 10. French Departements confirmed with Asian Hornet in 2012*

## 4.2 Foraging habitat loss

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 defences (Brodschneider and Crailsheim, 2010; Alaux *et al.*, 2010; Pederson and Omholt, 1993).

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 in general 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).

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 floral diversity are more likely to provide sufficient nutrition throughout the year, thus ensuring bee health.

In one of the reports published in the framework of the STEP project (STEP Project, 2011) it is noted that regarding the declines in insect pollinators "the most important factor is probably the land use changes that have occurred in the agricultural landscape after the Second World War (Winfree *et al.,* 2009). Suitable habitats have been lost when the proportion of semi-natural areas have decreased, which has affected the pollinator fauna negatively (Kremen *et al.,* 2004, Öckinger & Smith 2006). "

The conclusions of this report from the STEP project on the uptake of mitigation strategies counteracting pollinator loss across Europe indicate that:

- few protected areas are specifically targeted towards pollinators, but protection of habitat for other species may benefit pollinators
- mass-flowering crops can be a rich source of nectar and pollen, but the availability is often limited to a short time period
- semi-natural areas, grasslands or field borders, are important habitat for pollinators
- measures that increase pollinator nest/breeding site availability or quality or flower resource abundance have the potential to promote pollinators
- in several countries, there are different options to provide flower resources on farmland, such as sown strips of flowering plants or including flowering plants in fallows
- organic farming and unsprayed field margins, which both reduce herbicide use and thereby promote flower abundance, are frequently used
- for measures that have the potential to mitigate pollinator loss the approach is heterogeneous among EU member states
- measures specifically targeted at promoting pollinators, like for specifically providing nesting habitat are needed.

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 substitute during development (Wahl and Ulm, 1983).

One solution to mitigate dietary and habitat pressures encountered by pollinators is the use of multifunctional landscaping (OPERA, 2011). The use of buffer margins next to crops that reduce both spray and dust drift onto neighbouring fields and habitats protect 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.

## 4.3 Pesticides

Frequently 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 (see e.g. AFSSA, 2009; Barnett *et al.,* 2007, Seefeld 2008, Thompson & Thorbahn 2009). In this context, it is important to note that the most frequent causes of adverse effects of pesticides to bees 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.

### 4.3.1 Exposure of Bees to Pesticides and Pesticide Side Effects to Bees

The exposure of bees by pesticides is determined by a couple of different factors, for instance timing and type of application and attractiveness of the treated crop to bees.

Exposure can for instance be excluded when according to the type of application bees are not likely to come into contact with the applied product. 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 released), 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 point to consider is the attractiveness of the crop plant. In general, a crop is not attractive to bees when harvested before flowering. In this context, it has, however, to be considered that attractiveness of a crop may be influenced by factors other than the intrinsic attractiveness of its blossoms (e.g. flowering weeds in the crop, honeydew-producing aphids). A list of bee-attractive crops in Europe, based on data from the Netherlands, will be published in the scope of the upcoming EFSA Guidance Document on the Risk Assessment of Plant Protection Products on bees (EFSA in prep.).

These initial steps of exposure evaluation are considered in current risk assessment schemes (e.g. EPPO, 2010) and are acknowledged in updated proposed risk assessments in Europe (EFSA, in prep) and North America (ref to the USEPA white paper proposing a risk assessment to bees). Under the recently published EPPO guidance separate pathways on the decision tree are presented to cover the differences in exposure from sprayed and soil-applied products.

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 an incorrect application of a product classified as hazardous for bees.

Another path of exposure is via dust from seed coatings that may be emitted, in particular when vacuum-pneumatic planters are used for sowing. In certain crops (e.g. oilseed rape, sugar beets), potential exposure to dust is due to coating techniques and structure of the seeds a priori low to negligible, in others (e.g. maize) measures have to be taken to minimize dust emission. Exposure can vary depending on the quality of the seed coating (the better the seed treatment quality, the less dust is formed) and on the use of devices reducing dust emission, e.g. deflectors.

Technical solutions for effective risk mitigation of dusts exist and are in place in many Member States with positive results. Details of all relevant aspects of this topic and appropriate measures to ensure safety of seed treatment products will be outlined in a new EU Guidance Document on seed treatment that is anticipated to be issued in 2013.

The exposure of bees via uptake of guttation water containing residues of systemic insecticides has been discussed in the scientific community in the last years. Recent research data (Pistorius *et al.*, 2012; Keppler *et al.,* 2010) have demonstrated that 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 has been shown to decrease rapidly within a few meters distance of the colonies to treated crops.

### Sublethal Exposure to Pesticide Residues and Sublethal Effects of Pesticides

When colonies are monitored for pesticide residues, frequently sublethal concentrations of different compounds have been detected (e.g. Chauzat *et al.*, 2009, Genersch *et al.*, 2010, Mullin *et al.,* 2010; Johnson *et al.*, 2010, Bernal *et al.,* 2010). The composition of different active substances and residue levels are strongly linked with the local situation, the agricultural structure and local patterns of pesticide use, and beekeeping practices. 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, 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, Bernal *et al.,* 2010).

Frequently, sublethal pesticide residue concentrations found in nectar, pollen and bee bread are considered 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 sublethal-level residues of pesticides in bee hives and colony mortality has been found (e.g. Genersch *et al.,* 2010; Bernal *et al.*, 2010, Chauzat *et al.*, 2009).

Sublethal effects, especially of neonicotinoids, is a topic that has in the last years been intensely discussed in the scientific community – 23 scientific papers out of 47 papers dealing with effects of pesticides on bees between 2009 and 2012 (Miles and Alix, 2012), and in 2012 and the previous years, some publications on this topic have been issued that found considerable attention by the media (e.g. Henry *et al.*, 2012, Whitehorn *et al.*, 2012, Lu *et al.,* 2012, Gill *et al.*, 2012). The same is true for combination effects between sublethal doses of pesticides and other stressors, e.g. pathogens or veterinary products (e.g. Alaux *et al.,* 2010, Vidau *et al.,* 2011, Hawthorne & Dively, 2011, Pettis *et al.*, 2012).

Fundamentally, sublethal effects are defined as any kind of effects that do not kill an organism. This entails a huge diversity of effects to be considered here with very different traits and severities. This makes it very difficult to judge the importance of sublethal effects of pesticides for the health of bee colonies. Nevertheless, some general points are important to consider:

- Basically, sublethal effects do essentially just characterize a non-lethal difference between treated and untreated organisms as seen in a trial. It is not a priori given that such a difference entails any disadvantage for the affected organism, or, in other words, a sublethal effect is not necessarily an adverse effect, unless the contrary is shown by appropriate evidence.

- Many of the reported sublethal effects have been observed in individual bees, often in the laboratory or under otherwise artificial exposure conditions. However, it has to be considered that an individual bee may react differently in isolation or in an artificial environment than in the context of its colony. There are at least some cases where certain effects that were seen in the laboratory could not be recovered under field conditions with entire colonies being observed (for instance in Pettis *et al.*,2012), thus underlying the importance to distinguish the mechanisms from the causes.

- There are no validated testing systems in the laboratory for sublethal effects existing so far; therefore it is for many published effects not clear whether they could be reproduced, and in fact there are some results on sublethal effects that were so far published for some compounds seem to be conflictive with other published data.

- In many of the studies that describe sublethal effects, unrealistically high exposure concentrations of extreme exposure conditions were tested that are not representative for realistic field conditions. For instance, in some studies, were intake quantities of a whole day that were theoretically calculated on the basis of worst-case exposure figures administered to a bee all at once, or test colonies were chronically exposed to residue levels derived from high-end residue findings that are by an order of magnitude greater than typical residue levels in the field. Therefore, not all reported sublethal effects may be of relevance under practical field conditions.

- Finally, in numerous field studies that were conducted under realistic field conditions, no adverse – lethal or sublethal- effects were seen.

As an example of this, recent studies on sublethal effects (e.g. Henry *et al.* 2012, Whitehorn *et al.* 2012) were evaluated by EFSA and by ANSES (France). Both institutions came to the conclusion that exposure scenarios as applied in the discussed studies were not necessarily representative for realistic field conditions, and that further research would be needed before definite conclusions could be made about the significance of sublethal effects for the health of bees and bumblebees.

Although, based on the facts outlined above, there does not appear to be any strong evidence that sublethal effects of pesticides play a key role as causative factors behind bee colony mortality (which is likewise supported by the fact that in several monitoring projects no correlation has been found between colony losses and pesticide exposure), sublethal effects are certainly a point where more fundamental research is needed to obtain a clearer picture of the nature of the issue, before it can be reasonably decided whether and in which way it may be appropriate to consider which sublethal effects in regulatory risk assessment for bees. An exemplary approach to evaluate the importance of chronic, sublethal exposure to pesticides on colony level under realistic field conditions is for instance currently pursued in the framework of the German FitBee Project (http://fitbee.net).

Due to the importance of bees pollinators of both managed crops and wild flora a report was produced for EFSA (Thompson, 2012) in which an overview of the interactions between pesticides and other factors in effects on bees was considered: 1) The importance of the different exposure routes in relation to the overall exposure of bees to pesticides; 2) Multiple exposure to pesticides (including substances used in bee medication) and potential additive and cumulative effects; and 3) Interactions between diseases and susceptibility of bees to pesticides.

Nectar foraging bees are likely to experienced highest exposure to both sprayed and systemic seed and soil treatments compounds followed by nurse and brood-attending bees. In both cases the major contribution to exposure was contaminated nectar with direct overspray playing a significant role in exposure.

However, there are a variety of other routes (and other bee species) where there is currently insufficient data to fully evaluate total exposure: There are a large number of studies that have investigated the interactions between pesticides in bees. By far the majority have related to the interactions involving EBI fungicides and can be related to their inhibition of P450. The scale of the synergy is shown to be dose and season-dependent in acute exposures but there are few data relating to the effect of time between exposures, the effect of route of exposure or on chronic exposure effects at realistic exposure levels.

There are a wide range of factors which affect the immunocompetence of bees including diet quality, pest and diseases. Although there are a limited number of laboratory based studies which suggest effects of a pesticide on disease susceptibility there is no clear evidence from field-based studies that exposure of colonies to pesticides results in increased susceptibility, to disease or that there is a link between colony loss due to disease and pesticide residues in monitoring studies (Thompson, 2012).

### 4.3.2 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.

Active monitoring systems use pre-selected bee colonies that are regularly surveyed for their health in relation to defined influencing factors. In Europe, there is a wide variety of monitoring and surveillance systems for bee mortality and bee health; some of these focus on a broad view on all factors potentially influencing bee health but some focus mostly on specific concerns (e.g. the effects of pesticide exposure to 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).

#### Post Registration Monitoring Studies and other Pesticide- or Crop-Specific Monitoring Approaches

These approaches constitute active monitoring and are aimed at checking that the conditions of use of some specific plant protection 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 pesticides-related activities have focused on neonicotinoid seed treatment products in various crops. 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 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 exposure (French Ministry of Agriculture, 2011).

Another monitoring approach that was conducted in France has been published by Chauzat *et al.,* (2009) as a part of a multifactorial monitoring project. In this survey, in total 125 bee hives from 25 apiaries which were locate in five different regions of France were surveyed over three years for their health status and potentially influencing factors, among them pesticide residues in hive matrices. No correlation between in-hive residues of pesticides and bee colony mortality has been found in this study.

#### Germany

The most important large-scale monitoring project in Germany is the German Bee Monitoring that is on-going since 2004 (interim results published by Genersch *et al.*, 2010). Exposure to in-hive residues of pesticides and exposure to typically neonicotinoid-treated crops like oilseed rape and maize also belong to the parameters assessed here, but as the focus generally on factors that influence overwintering capacity, also other factors that may influence bee health, like Varroa, viruses and other bee diseases are investigated. So far, no correlation was found between exposure to pesticide residues or exposure to neonicotinoid-treated crops and colony mortality but a strong link with the losses observed in winter and bee diseases, especially Varroa and secondary virus infections.

A more small-scale approach to specifically evaluate the bee safety 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, 2011 and 2012, 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 (e.g. hops). Although individual exposed bee hives displayed more or less pronounced mortality peaks on single days when exposed to guttating maize fields, no adverse effects on the colony level were observed (Illies *et al.*, 2012a). In hops, no adverse effects to bee colonies by a thiamethoxam soil treatment were found (Engelhard *et al.*, 2011, Illies *et al.*, 2012b).

### Italy

Further activities to monitor potential effects of neonicotinioid seed treatment, particularly in maize, to honey bees, have been conducted in the framework of the APENET Monitoring in Italy. Results are reported by CRA-API (2009, 2010, 2011). The reports do not refer to significant issues related to pathogens, but describe 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, 2011) other useful data are reviewed based on descriptive monofactorial analysis of the potential risk and data monitoring in field. Mitigation measures are proposed.

In 2012, EFSA reviewed the APENET Report (EFSA, 2012) and came to the conclusion that, though some concerns were seen related dust exposure and potential effects on bees, "overall, due to some deficiencies in the study designs, weakness in the statistical analysis as documented and incompleteness in the reporting of results, it was not possible to draw a definitive conclusion on all the scientific information."

### Austria

Another monitoring project with focus on neonicotinoid seed treatment products is the MELISSA Project in Austria that was conducted in the years 2009-2011. In this project, particular attention was directed to the investigation of any damage to bees that is reported in association of growing maize and oilseed rape. (Final report: Girsch and Moosbeckhofer, 2012). A relatively limited number of incidents which are likely to be related to dust exposure to seed treatment products in maize were yearly recorded from a few regions in Austria, mostly where small-scaled landscape structures prevail. Number and severity of these cases was reported to continuously decrease from year to year which shows that the prescribed safety measures can be protective when consequently applied.

### 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.

### Spain

A monitoring study from Spain to evaluate the exposure of bees to pesticide residues in stored pollen and to determine potential effects of pesticide exposure to colony mortality is reported by Bernal *et al.*, (2010). In this study, more than thousand apiaries were surveyed. Pesticide residues were found in up to 42% of the analyzed samples, most frequent residues came from anti-Varroa treatments. Residues of Neonicotinoids were not found. No correlation was seen between pesticide exposure and colony losses. Results on anti-Varroa treatments are consistent with the findings of many pesticide residue monitoring projects, (see introduction of chapter 4.3.1). Similar situation we can find in France where anti-Varroa treatment residues are mentioned (AFSSA, 2009) , for example residues of coumaphos are quite often found at very high concentrations in hive matrices.

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 still contains some uncertainties regarding extrapolation to all conditions of use. Moreover, such monitoring approaches can reveal the necessity of stewardship measures for individual product types and test for the effectiveness of implemented stewardship measures.

### 4.4 Genetic diversity and resilience to pests and diseases

In 2010, Meixner *et al.* has pointed out the importance of genetic diversity of bees in developing resilience to pests and diseases. The most important points of this paper are summarized here. Today, virtually the entire honey bee population of Europe consists of colonies managed by beekeepers, probably as a consequence of the destruction of the natural habitats and the spread of the mite Varroa *destructor.*

The protection and proliferation of the species *A. mellifera* and its subspecies in Europe today entirely depends on beekeeping activities, and one consequences of these activities has been the spread of the commercial most interesting subspecies *A. m. carnica, A. m. ligustica* and *A. m. caucasica* through the importation of queens.

Of course, this has brought to a disadvantage of the respective native subspecies or ecotypes and has caused the reduction or loss of genetic diversity, since characteristic traits of the autochthonous subspecies may become endangered or lost by introgression of foreign subspecies.

It seems that genetic diversity is very important to avoid colony losses. In its native range of Africa, Europe, Western and Central Asia the honey bee *Apis mellifera L.* has adapted to a wide variety of ecosystems: about 26 subspecies have been described, 10 of which live in Europe.

Europe has a wide variety of landscapes and weather conditions, so, during the years, each different species adapted to the specific characteristic of the area. Local adaptation implies that over generations some colonies will do better than others, and this happens because they are well suited to their environment and their pathogens.

At the colony level, genetic variability has been shown to be important for disease resistance, homeostasis, thermoregulation and overall colony fitness (Tarpy, 2003; Jones *et al.,* 2004; Graham *et al.,* 2006; Mattila & Selley, 2007). The selective breeding approach - made by comparing the performance of colonies in a number of traits that are considered of major apicultural interest, such as honey production, temperament, swarming tendency and quietness on the comb - neglecting resistance traits against diseases may leave the selected population with a reduced capacity to ward off stressors.

Moreover, colonies genetically similar in wide areas may also increase the chances of disease transmission and loss of colonies, with the high risk for beekeepers of losing honey and of potential breeding stock.

The existing subspecies and ecotypes of honey bees in Europe represent an important resource for breeding of diseases and stress resistant strains. Anecdotal evidence suggests that locally adapted strains of bees suffer less from elevated losses than non-native honeybees.

The development of natural resistance against parasites has been well characterized in the case of *V. destructor* (Fries & Bommarco, 2007; Le Conte *et al.,* 2007; Rinderer *et al.,* 2001; Seeley, 2007), and while criteria like resistance against pathogens and parasites are of little importance in traditional breeding protocols, recent projects increasingly bring the development of traits related to colony vitality into focus.

These projects introduced and evaluate additional traits related to colony vitality, such as hygienic behaviour, mite infestation development and overwintering ability. The aim is to improve the mite resistance of the selected stock without sacrificing traits that are of importance for beekeepers.

Moreover, a new concept of tolerance mating stations has been developed, where drones of the selected population are reared under high infestation pressure in colonies that remain untreated for a long time. The basic idea is to introduce elements of natural selection into the breeding protocols, rather than preventing it from taking place.

## 4.5 Risk Management for pests, diseases and pesticides

Regarding an update on risk mitigation the main input publicly available relates to the STEP project (http://www.step-project.net/) and a preliminary review of mitigation options to limit pollinator losses as part of the Work Package 4 (Potts *et al.,* 2011).

STEP is a project aiming at providing the best picture possible on European pollinating species through research projects involving surveys that allow the identification of species at risk of decline, the relative importance of potential drivers of such change, including climate change, habitat loss and fragmentation, agrochemicals, pathogens, invasive alien species, light pollution, and their interactions. STEP also works at the development of a Red List of important European pollinator groups, in particular bees. Eventually this meta-analysis includes an estimation of the ecological and economic impacts on declining pollinator services and floral resources including effects on wild plant populations, crop production and human nutrition.

STEP is analysing existing datasets generated in conservation initiatives with the aim to identify mitigation options being effective on pollinators and pollination. This includes initiatives at local and broader scale, nature reserves, agri-environment schemes or organic farming.

STEP also collects data from European and national institutions. This analysis aims at identifying the factors of success of a mitigation initiative, in order to propose recommendations. A study of these data for England has been published (Breeze *et al.,* 2011). Out of the 31 recommendations, 21 deal with the promotion of habitat creation or conservation at measures at the farm, regional and national scale, some of them linked to the CAP.

Regarding bee health and pathologies, COLOSS is the reference to provide recommendations regarding mitigation measures but the on-going project did not lead to the publication of recommendations in the area of risk management (http://www.coloss.org/news).

OECD PEIP is building a portal on risk management which will provide a link to actions and policies in OECD countries regarding risk mitigation measures related to pesticides (see also chapter 6.4).

# CHAPTER 5. ECONOMIC FACTORS INFLUENCING HONEY BEE POPULATIONS

## 5.1 Honey: production, prices and trade.

The latest available data from FAO highlight that in 2010 the honey production all over the world was of 1.54 million tonnes (FAO, 2012). The top five producing countries were China, Turkey, United States of America, Ukraine and Argentina. The European contribution to this was 23%. The top European producer is Ukraine (70900 tons), followed by the Russian Federation, Spain, Germany and Romania.

In 2010, according to FAO data, the largest importers for honey were the USA, Germany, United Kingdom, Japan and France, whereas the primary exporters were China, Argentina, Germany, Mexico and Spain. In 2010 in Europe 239,646 tonnes of honey were imported, and 116,728 were exported. The only European countries where there was a positive balance of trade were Eastern Europe Countries (Bulgaria, Croatia, Czech Republic, Hungary, Lithuania, Republic of Moldova, Romania, Serbia, Slovakia, Ukraine) and Spain.

Overall the price of European honey has increased between 2009 and 2010. However information is not available for all Member States - there are no data for Belgium, Czech Republic, Finland, France, Germany, Ireland, Italy, Russian Federation or Slovakia. The price of honey has definitely an impact on the profitability of the beekeeping activity. Variations in the number of colonies might be associated with these economic aspects.

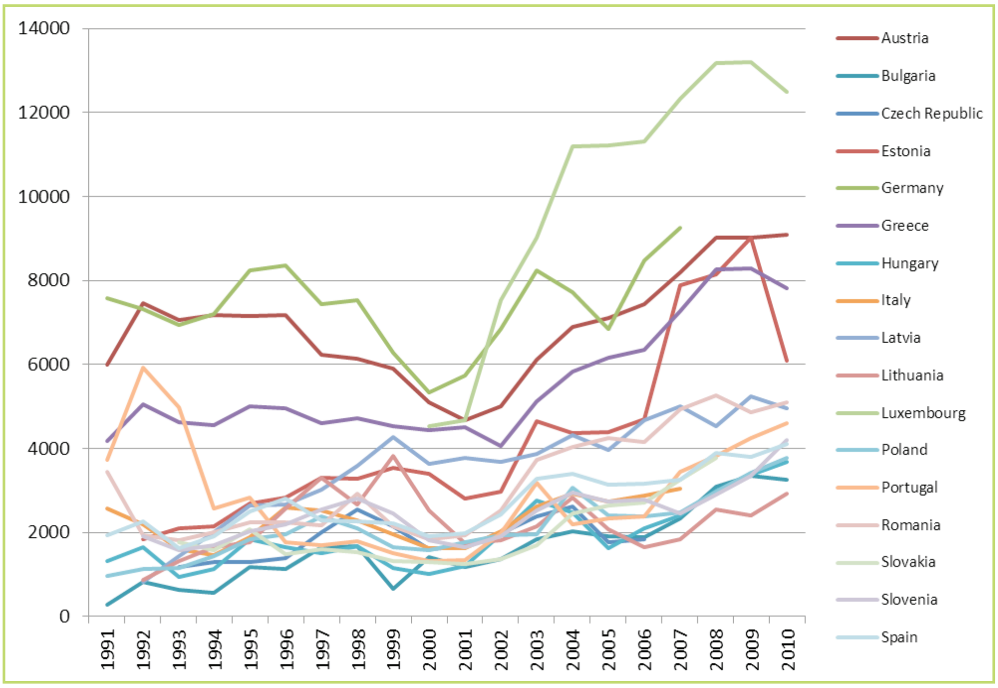


*Figure 10. Price of honey in EU countries in Euro/tonne (Data source: FAOSTAT, 2012 )*

With EU maintaining over the years a relatively constant deficit of honey in international trade, up to one third of the total consumption, the pressure generated by the low prices of imported honey (especially from China) is affecting the market of the European producers.

## 5.2 Cost structures and challenges for beekeepers

As pointed before, beekeeping is not always a simple activity to undertake. Beekeepers are faced with many different challenges: an analysis of the cost structure of honey production is useful to confirm this.

Among the fixed costs in beekeeping we can include costs related to materials, transport, buildings, tax, insurance and depreciation, while for variable costs those linked to the number of beehives, as costs for feeding the bees, for transhumance, the conditioning and for the bee health treatments, especially against varroosis.

The price of materials and disease treatments are relatively high, so the costs of beekeeping often exceed the income generated. It is reasonable to assume that costs can vary from one country to another, depending on some factors such as labour costs, the national tax system, and of course the geographical and meteorological conditions. However, analyzing the National Programs elaborated by some Member States for the purpose of supporting the apiculture sector (see chapter 6.5 for details), can be seen that the cost for a family is around 62 €. Fixed costs are the greatest, comprising 50% - 70% of the total.

The initial investment when starting beekeeping is also significant, the Spanish Apiculture Program, for example, reports an investment of 80,430 € for 500 hives (160 €/hive).

As said before, costs can vary greatly from one country to another, hence a comparison of national data is difficult. The entire sector has to cope with different challenges. First of all, fixed costs are very high. For this reason, keeping bees on a small scale is often not cost effective, and often the costs of beekeeping exceed the income generated. Of course, profit is essential for professional beekeepers.

Among variable costs, the greater part is for the bee health treatments (primarily Varroa control) and for migration. This is reflected also in Council Regulation 1234/2007 on "establishing a common organization of agricultural markets and on specific provisions for certain agricultural products". The control of varroosis and the rationalization of transhumance are among the actions that can benefit of European co-financing. The National Program drafted for the implementation of this regulation does confirm this, as the majority of the budget to support apiculture is given to these two areas.

### France

Because of the relatively large size of France beekeeping and honey production throughout France varies greatly from region to region, there are also annual differences based on geographical location and varying climatic conditions.

The honey chain is complex with many interactions, production systems, trade and marketing strategies etc. According the national plan for the apicultural sector, the majority of producers are hobbyist beekeepers, not professional: in 2008, the professional beekeepers represented approximately only 2% of the total, operating more than 55% of the colonies.

Regarding the costs for French honey producers, available data are minimal. However, France appears to have the lowest costs per hive: 50 € (including fixed and variable costs).

### Spain

Professional beekeepers manage 80% of beehives in Spain. According to data presented in the national plan, in 2008 the percentage of professional beekeepers (classed as those with more than 150 hives) in Spain was fairly stable (there was a slight apparent decrease) at 22.51%, where in the previous three years they had represented 24.66% of managed colonies.

The Spanish National Plan, includes an economic analysis of the costs and the revenues for a beekeeper with 500 hives. The example includes financial aid from European Union. It is interesting to see that the price improvement of honey, along with financial aid, allows a higher net return compared with the previous period; at the same time, the production costs for honey increased, mainly due to higher fixed costs (e.g. taxes, insurances, fuel). Moreover, it is also possible to see a decrease of the revenue coming from the sale of hives (due to the mortality). The cost per a single beehive in Spain is evaluated at €52.58.

### Romania

In Romania, the breeding of bees has developed thanks to exceptionally favorable natural conditions. Romania has a well developed beekeeping industry with a large number of apiaries and hives and large scale honey production all aided by, the diversification of beekeeping production, the results of scientific research and the training of specialists.

In Romania, according to information in the National Plan for 2011 - 2013, the costs for a bee hive is 68 €. Here, large percentage is down to labour costs. The cost to produce a kilogram of honey, (based on owning 60 beehives) is approximately 2.72 €, while the income is 1.76 €/kg, hence the need for support to cover certain costs.

### Hungary

National Program (2004 - 2006) figures indicate, the costs to manage a single bee hive is 66.14 €. The fixed costs account for 60% of the total. The amount of the variable costs is 26.76 €, of which the biggest part is for transhumance.

The main problem in Hungary, as in other countries, is the Varroa mite. Moreover, Hungary is exposed to the risk of epidemics because of the high density of hives. For this reason, for the period 2004 - 2006, the majority of the financial aid from European Community was used for managing Varroa.

# CHAPTER 6. INITIATIVES AND POLICIES TO ADDRESS THE PROBLEM

## 6.1 European Union Reference Laboratory for honeybee health

In February 2011, the EC officially appointed the Sophia-Antipolis Laboratory of ANSES, France (French National Agency for Sanitary Safety of Food, Environment and Labour, formerly AFSSA [http://www.anses.fr/]) as the EU Reference Laboratory (EURL) for honey bee health.

Its responsibilities are established by the Article 32 and 33 of Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls, as well as by the Commission Regulation (EU) No 87/2011 of 2 February 2011 designating the EU reference laboratory for honeybee health.

Based on the analysis that was made by EFSA (EFSA 2009), data that were collected from surveillance networks gave the "global colony rate" during the overwintering period as the only indicator that appeared to be commonly used. Important colony losses were shown by temporal and geographical analyses. However the analysis clearly defines the need for shared epidemiological indicators that will be collected following common surveillance procedures and will be based on comparable populations.

The European Union Reference Laboratory for honeybee health recommends improvement of the representativeness of collected data and harmonisation of surveillance procedures at European level in order to make possible a consistent estimation of colony losses in Europe.

The first action of the EURL has been to address the knowledge gap by initiating a Pilot Surveillance Programme (PSP) to collect standard baseline data on colony losses and honey bee health from across the EU. In June 2011 they published a document entitled "Guidelines for a pilot surveillance project on honeybee colony losses". The purpose of this document is:

- to revise of the general principles that constitute the basis for accurate and strategic surveillance
- to draw conclusions on perspectives and requirements of future surveillance of honeybee colony losses
- to propose a surveillance framework to be used by European MS who may be interested in applying for a project grants to allow them to implement a relevant and effective system
- to provide to future applicants useful recommendations and to assist in the design and improvement of surveillance systems.

This sampling for the PSP started in the autumn of 2012. The data from this will be published (in 2013) which will give a more comprehensive understanding of disease presence and prevalence and the numbers of losses throughout Europe. The European Commission provides financial support the member states participating in this surveillance programme, covering up to 70% of the costs incurred by the specific activities to collect the data.

## 6.2 Authorisation procedures for veterinary products to control pest and diseases in bees

The fees for the authorisation process of a veterinary medicine in the EU are very reasonable compared to those of a plant protection or biocidal product. Therefore, we do not believe that the fees alone would be a significant barrier to a new honeybee medicine. The real barrier to obtaining an authorisation of a new honeybee medicine are the costs of studies for the dossier, and the need to comply with Good Manufacturing Practice (GMP) as a pharmaceutical. Other examples of high costs include analytical method development and shelf-life studies.

The need for setting up a pharmacovigilance system in Europe is one of the challenges that can delay the authorisation procedure and is a significant contribution to the cost of obtaining an authorisation, and is an ongoing operating cost. Since the product is finally addressing a relatively small market, all these significant costs have an effect on the economic viability of putting a new product on the market. Hence companies that have developed solutions to fight various bee pests in other parts of the world are reluctant to authorizing them for the use of European beekeepers.

It is widely recognised in the EU that efficient treatments for honeybee colonies are urgently needed. For the future development of new bee medicines, a collaborative approach between all the stakeholders is a necessity. Also, a more pragmatic approach to the data requirements for MUMS (minor use/minor species) products would be helpful. A MUMS medicine is by definition a niche product, with relatively low potential for return on investment, but the current MUMS system in the EU does not provide a large enough reduction in the dossier requirements to promote a real incentive to the development of new bee medicines.

Given that the requirements are harmonised across Europe by the EU Directive 2001/82/EC (as amended), we would suggest that one way to both reduce costs to the applicant and to speed up the availability of new products to the beekeepers would be to allow automatic mutual recognition by a simple notification process via either the Reference Member State or EMA.

## 6.3 Pesticides regulatory activities on bee health

### 6.3.1 EU

The evaluation of the impact of pesticides on bees has been carried out for many years in Europe. The current EU Regulation 1107/2009/EC on pesticides includes a specific requirement for risk assessment on honey bee *(Apis mellifera)* and replaced the approval procedure under the previous framework, Directive 91/414/EEC. Directions for testing and risk assessment for honey bees are given in the EPPO Testing Guidelines and Risk Assessment Schemes (EPPO 2010a, b).

The European Food Safety Authority (EFSA) is currently revising the European Guidance Document on terrestrial ecotoxicology and in the context of this revision; bees risk assessment is also revisited. Considering the importance and the sensitiveness of this issue, and in line with the aim of the Commission Communication on Honeybee Health (COM 2010), the Commission specifically requested EFSA to develop an Opinion on the science behind bee risk assessment, which would then be used to draft a new Guidance Document on the risk assessment of Plant Protection Products on Bees. This EFSA Opinion was also broadened to include *Bombus* spp and solitary bees as well as honey bees.

The EFSA Scientific Opinion on the science behind the development of a risk assessment of Plant Protection Products on bees *(Apis mellifera, Bombus spp.*, and solitary bees) was published in May 2012 (EFSA2012a). It was guided by the terms of reference provided by European Commission and covered the following issues:

- The assessment of the acute and chronic effects of Plant Protection Products on bees, including the colony survival and development
- The estimation of the long-term effects due to exposure to low concentrations
- The development of a methodology to take into account cumulative and synergistic effects
- The evaluation of the existing validated test protocols and the possible need to develop new protocols, especially to take into account the exposure of bees to pesticides through nectar and pollen.

The different routes of exposure were analysed in detail for different categories of bees. The existing test guidelines were evaluated and suggestions for improvement and further research needs were listed. A simple prioritisation tool to assess cumulative effects of single pesticides using mortality data is suggested. Effects from repeated and simultaneous exposure and synergism are discussed. Proposals for separate risk assessment schemes, one for honey bees and one for bumble bees and solitary bees, were developed.

Specific protection goals based on ecosystem services were suggested according to the methodology outlined in the Scientific Opinion of EFSA (2010). Pollination, hive products (for honey-bees only) and biodiversity (specifically addressed under genetic resources and cultural services) were identified as relevant ecosystem services. It was suggested to define the attributes to protect as survival and development of colonies and effects on larvae and honey bee behaviour as listed in regulation (EC) No 1107/2009. In addition, abundance/biomass and reproduction were also suggested because of their importance for the development and long-term survival of colonies.

The opinion will be the scientific basis for the development of a Guidance Document on the Risk Assessment of Plant Protection Products on bees, which should provide guidance for applicants and authorities in the context of the review of Plant Protection Products (PPPs) and their active substances under Regulation (EC) 1107/2009. The Draft Guidance Document (EFSA 2012b) was published in September 2012. This draft Guidance Document has been proposed for public consultation in order to give stakeholders and the interested public the opportunity to comment.

This draft Guidance comprises a tiered risk assessment approach covering new exposure routes such as residues in nectar, pollen, guttation droplets and dust and also assessing exposure and risk to different life stages of bees and including investigating new sub-lethal endpoints and proposing new sub-lethal studies. A precautionary worst case approach to exposure assessment and new conservative risk assessment trigger values are proposed. For semi-field and field studies new methods must be developed with improved sensitivity and statistical power. A new risk assessment scheme with even more conservative trigger values than for honeybees, is proposed for both bumble bees and solitary bees, along with an urgent recommendation to develop new higher tier methods for these species.

Currently, EFSA has received a number of comments in the course of the public consultation of this draft Guidance Document from public, authorities, scientists and industry, as it seems very important to maintain a risk assessment scheme which effectively sorts out compounds with no concern from those with potential concern. Such a scheme needs to be produce data that can be reliably used for risk assessment. Proposed studies need to be suitable to produce meaningful, reliable and replicable data to enable a reasonable tiered approach with laboratory, semi-field and field studies; it is necessary endpoints are measurable and meaningful, the aim, extent and conduct of studies reasonable, manageable and practicable. The endpoints and study protocol need to be precise ensuring sufficient flexibility. Currently, the document is under revision with respect to the comments received.

### 6.3.2 USA

From October 15 – 17, 2012, a National Stakeholder Conference on Pollinator Heath took place in Washington DC that was funded by U.S. Department of Agriculture (USDA) and hosted by Pennsylvania State University. The meeting included federal and university scientists and stakeholder communities including beekeepers, agricultural industry, and others to discuss the status of managed honey bee health in the United States.

The meeting focused on the primary factors affecting honey bee health such as nutrition, pests and pathogens, pesticides, genetics and breeding and bee management, as well as the current state of scientific knowledge on Colony Collapse Disorder (CCD), a syndrome that began causing major losses of managed honey bees in 2006 and for which no cause has been definitively established.

The conference provided valuable input from stakeholders on best management practices and emphasized the need for more effective communication and collaboration between government, academia, industry and the general public and identified areas in which additional research is needed.

In a recent White Paper (USEPA 2012a), the U.S. Environmental Protection Agency in collaboration with Health Canada's Pest Management Regulatory Agency and the California Department of Pesticide Regulation describe an approach for quantifying the potential risks of pesticides to honey bees.

The proposed process is consistent with that used for by these regulatory authorities for other taxa in that it is both iterative and tiered and takes into account both foliar pesticides as well as those which are distributed systemically in plants. Increased levels of refinement focus on areas where specific risks may exist and are intended to be increasingly representative of actual use/exposure conditions.

The overall proposed approach is a tiered process whereby risks are first assessed using simple and conservative exposure screening models to generate estimated environmental concentrations (EECs) coupled with toxicity estimates derived from laboratory studies (Tier I) to calculate risk quotients (RQs). If risks are identified in Tier I *(i.e.*, where risk estimates exceed levels of concern, additional data may be used to refine the results such as using estimates of exposure derived from available magnitude of residue or other commonly submitted studies.

If risks are still identified after refinement with available data, then appropriate risk mitigation options may be identified and further evaluated for their impact on risk estimates. Alternatively (or in addition), a higher-tier assessment may be necessary (Tier II) and studies providing refined estimates of exposure *(e.g.*, field studies quantifying residues in pollen and nectar); and effects at the colony level (e.g., semi-field tunnel studies or field-level feeding studies) may be requested. Measured residues in pollen and nectar from these studies may be used to refine risk estimates from Tier I and/or for qualitatively evaluating risk at the colony level associated with pesticide applications. They may also be used to identify more targeted risk mitigation options than those that could be identified based on Tier I risk estimates.

Available data from toxicity of residues on foliage studies are used qualitatively to characterize the length of time that residues remain toxic to bees. The results of the guideline study may result in precautionary label statements similar to those discussed in the EPA Label Review Manual (USEPA 2012b) or in guidance documents intended to reduce the potential effects of pesticides on bees (*e.g.,* Riedl *et al.*, 2006).

If available risk mitigation options do not provide for an acceptable reduction in risk, proceeding to Tier III may be necessary to resolve specific uncertainties identified from Tiers I and II for the proposed uses of the pesticide.

Although this white paper focuses on honey bees, the process described herein applies to both individual bees and to the colony and thereby is applicable to other insect pollinators, in particular non-Apis bees. The paper acknowledges the limitations in this assumption. While some toxicity testing methods may be available for evaluating effects to non-*Apis* bees, these tests have not been sufficiently vetted at this time to support their use in quantifying risks to these other taxa.

## 6.4 International Organisations interested in honey bee and pollinators

Beside a number of laboratories dedicating their research activities to pollinators, many organizations participate to research and/or the organisation of research in order to advise in the area of honey bees and/or pollinators.

ICPPR (International Commission on Plant Pollinator Relationship) (http://www.uoguelph.ca/icpbr/)
ICPPR is a dedicated organisation involved into honey bee health issues since 1951. The work is organised around four working groups dealing with i) issues related to nectar quality, ii) pollination, iii) bee protection and iv) policy & regulation.

As an example the bee protection working group has had a continuous activity in gathering updated science in support of regulatory policies over the last 30 years. Identified risks and other needs for improvement of the risk assessment scheme are elaborated in specialised working groups that consist of volunteering experts from regulating authorities, industry, academia and others. Proposals from working groups are presented and discussed in the symposia, further elaborated by the working groups, and offered to EPPO for organising the international comments, support and agreements by all EPPO members states. The outcome and recommendations of the group have been used as a basis of EPPO guidelines for testing the toxicity of pesticides to bees.

Currently five subgroups are focusing their efforts on the improvement of regulatory testing in the area of i) the risks posed by seed dusts that may contain pesticides, ii) the risks posed by guttation, iii) the revision of semi-field and field studies, iv) the testing effects on honey bee larvae and v) monitoring the effects of pesticides to bees, with activities extended to pollinators since 2011. The last proceedings of this group are covered in a publication of the Julius Kühn Institute available online (http://pub.jki.bund.de/index.php/JKA/issue/current).

EPPO (European and Mediterranean Plant Protection Organization) (http://www.eppo.int/)
EPPO is an intergovernmental organization responsible for European cooperation in plant health in 50 countries covering Europe and Mediterranean regions. This is an important organisation participating in global discussions on plant health organized by FAO and the IPPC (IPPC: International Plant Protection Convention) secretariat.

EPPO has produced a large number of standards and publications on plant pests, threats to cultivated plants and related regulations, and plant protection products. In this respect, EPPO is charged to promote the use of modern, safe, and effective pest control methods and relies for this on the work of expert groups such as ICPPR and contributes in such way to the spreading of updated test guidelines and recommendations to a number of countries. EPPO has worked on the topic of honey bees since the 1990ies and produced and published the first guidelines for field studies on honey bees and the related guidance document for risk assessment. Ecotoxicological testing and risk assessment for honey bees is currently regulated by testing guidelines and risk assessment schemes issued by EPPO (EPPO 2010a, b).

OECD (Organization for Economic Co-operation and Development) (http://www.oecd.org/)
OECD has dedicated activities on honey bees since the 80ies and coordinated the development of the first test laboratory guidelines on honey bees as well as a method for testing effects in field tunnels.

In 2009, the OECD Pesticide Effects on Insect Pollinators (PEIP) working group has been created. The objective of this group is to provide OECD countries with a toolbox for the risk assessment, the risk management and incident reporting about pollinators. The working group counts 27 experts around four components that relate to understanding and potentially mitigating the potential effects of plant protection products (pesticides) on insect pollinators, including honey bees and non-*Apis* species:

- Communication on pollinator-related incidents between OECD member countries, through the development of a portal to share information on pesticide incidents involving pollinators, primarily honeybees, among the regulatory authorities of OECD countries;
- Identification and improvement of pesticide exposure and toxicity study methods toward enhancing insect pollinator risk assessment methodologies, through the inventory of existing test guidelines for laboratory and field studies for exposure, and acute and chronic effects to individual bees, larvae and/or colonies from pesticides;
- Identification and enhancement of current risk mitigation measures based on sound science and develop a portal to share risk management tools in order to mitigate the risk to pollinators;
- Collect global research efforts on examining and potentially mitigating the effects of pesticides on insect pollinators and develop a portal on research activities and definition of criteria to enter as relevant information.

**FAO (Food and Drug Administration)** (http://www.fao.org/biodiversity/components/pollinators/en/)
The FAO is another major contributor to the protection of pollinators, particularly the promotion of research projects, data collection and organisation having provided a better knowledge of the presence, role and importance of pollinators in agriculture. This activity is grouped into the Global Action on Pollination Services for Sustainable Agriculture but also in the development of pollinator initiatives in Africa, Brazil, Europe, North America and Oceania. The FAO funds research projects and tests the methods developed as for example with the ALARM project in Europe, aiming at Assessing Large Scale Risks for biodiversity.

## 6.5 National Plans in the EU to support apiculture

The European Commission (EC) provides support to the beekeeping sector through the Council Regulation (EC) No. 1234/2007. By the Commission Regulation (EC) No 917/2004, the EC gives detailed implementing measures to improve the general conditions for the production and marketing of apiculture products. Member States (MS) submit a three year National Apiculture Program to specify their intended activities.

Up to 50% of the costs incurred in the implementation of the programs will be financed by the EC. The funding varies based on the number of hives of each MS.

According the Article 2 of the COUNCIL REGULATION (EC) No 797/2004, the measures which may be included in the National Apicultural Programs are the following

1. Technical assistance to beekeepers (training courses etc.)
2. Control of varroosis
3. Rationalization of transhumance (colony migration)
4. Physico-chemical analysis of honey
5. Restocking of hives
6. Applied research in respect of beekeeping and apiculture products

The activities that gather the highest interest within the National Apicultural Programs are the first two, the technical assistance to beekeepers and the control of varroosis. Technical assistance to beekeepers such as: training courses to beekeepers, informative brochures, dissemination activities, appear to be one of the measures that MS invest the support of their national apiculture. The problem of varroosis which affects bee health is reflected in the majority of the national apicultural plans.

A short description of the apicultural National Plans of some Member State will be given to highlight their priorities.

Austria

The main focus of the Austrian plan is on the production of honey and the other bee products as well as the contribution to the preservation of ecological balance. Therefore, the objectives will support a nationwide beekeeping, the contribution of bees as pollinators, the prevention of bee diseases and they will ensure the absence of pesticides residues in bee products.

France

The French apiculture plan adopts all six measures to improve the production conditions and the marketing of the apicultural products.

Technical assistance will be provided to professional and hobbyist beekeepers by programs at national and regional level.

Regarding the varroosis, the program includes some actions towards applied research on the field of alternative methods against Varroa; research for new treatments against Varroa and monitoring the effectiveness of products against Varroa.

In 2012-2013 beekeepers will be supported to expand their hives. In addition, it is intended to support conservative management of bee species to preserve and/or maintain specific genes that can be recovered a posteriori.

Ireland

The main objectives of the Irish National Apicultural Program for 2010-2013 are to develop protocols for alternative methods that will advance control of Varroa; collect information on Irish colony losses in a manner that will be directly comparable with work in the other EU Member States and provide technical assistance and disseminate information on good practice to the beekeeping communities.

Greece

The Greek national apicultural program will provide technical assistance to beekeepers through the development of apicultural centers, an on-line apicultural network and training courses to the beekeepers. Additionally it will support the promotion of honey and other apicultural products. Furthermore, the program focuses on the rationalization of transhumance; the physico-chemical analysis of honey and the applied research in respect of beekeeping and apiculture products.

Poland

All six measures that are proposed by the EC will be adopted by the Polish National Apicultural Program. Some of the measures that will be implemented are the organization of training courses and conferences; purchase of beekeeping equipment; purchase of treatments to combat Varroa; purchase of trailers to transport hives; purchase of laboratory equipment; performance of quality analysis on honey; queens' purchase and implementation of research programs.

### Romania

The Romanian program focuses into supporting preventive and control activities of varroosis, together with the development of the guideline for best beekeeping practices.

Technical assistance to beekeepers will be provided by a guideline of best practices for beekeeping. This document will be produced by a working group of experts and will be approved by the Ministry of Agriculture and Rural Development. Other informative materials, flyers, posters and brochures will be produced and distributed as well.

Since there is a region of Romania which is still not affected by Varroa, measures are foreseen to coordinate preventive actions throughout the country.

### Spain

The main objectives of the program are to strengthen the professionalization of the sector and achieve greater modernization incorporating the latest technical and scientific advances. It also aims to improve the production and marketing systems and open new markets. The Spanish program focuses on the technical assistance to beekeepers; control of varroosis; rationalization of transhumance; physico-chemical analysis of honey and applied research in respect of beekeeping and apiculture products.

To be eligible for aid under the National Program, all beekeepers shall perform at least one treatment per year against varroosis and have liability insurance.

### UK

The Department for Environment Food, and Rural Affairs (Defra) and the Welsh Government launched the Healthy Bees Plan in March 2009. The Plan is being implemented by the Food and Environment Research Agency (Fera) in partnership with beekeeping stakeholders. The main targets of the health program are:

- To keep pests, diseases and other hazards to the lowest levels achievable
- To promote good standards of husbandry to minimize pest and diseases risks and contribute to sustaining honey bee populations
- To encourage effective biosecurity to minimize risks from pests, diseases and undesirable species
- To ensure that sound science underpins bee health policy and its implementation
- To get everyone to work together on bee health.

Furthermore, the program focuses on the provision of technical assistance to combat and control bee pests and diseases.

As previously highlighted, Member States receive financial support to be used for improvements in the production and marketing of apiculture products. The latest programs for the 27 EU States were approved in 2010, for the period 2011 - 2013. Compared to the previous period (2008 - 2010), the budget has been increased by almost 25%, € 26 million to € 32 million per year.

National Programmes are a fundamental part of the means to offset the loss of bees: according to the analysis conducted by the Commission, Member States have been satisfied with the benefits provided by these programmes and beekeepers have widely recognized the efficacy and positive effects of these measures.

# CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

## CONCLUSIONS

### 1. Trends in honey bee populations

The number of beehives has remained fairly constant in the past decade, with a slight increase between from 2000 to 2006. The causes for the fluctuations in numbers over the years are not easily identifiable. These can be attributed to climatic conditions, pests and diseases or simply to economic conditions which may influence the profitability of beekeeping. According to FAO data for the period 1992 - 2010, 16 million of bee hives existed, on average, in Europe.

Some agricultural land use practices can favour bees, flower rich meadows, orchards, hedges, flowering crops, field margins and buffer strips can all provide valuable food sources and habitats for bees. Further measures to provide incentives to farmers to set up flowering areas may provide an essential improvement of bee health and diversity.

The European Commission recognises that the apiculture sector needs to be addressed within policy measures. One of the drivers for continued support to the sector is the increasing negative impact of Varroa on bees and beekeeping.

COLOSS reports that in most European countries the losses identified by hobbyist beekeepers were higher than those by beekeepers with operations of intermediate size. Between 2008 and 2012, winter losses ranged from 7 to 30% with variations between countries and between years for the same country. No clear overarching trend can be highlighted.

In the US over winter losses from 2010-2011 were 29%. Since 2006 the overwintering losses reported for 2006-7, 2007-8, 2008-9 and 2009-10 were 32%, 36%, 29% and 34% respectively. The reasons that were most frequently identified by beekeepers for these losses were: starvation, weak colonies in the fall; poor wintering conditions; poor queens and Varroa mites.

Reporting schemes of pesticides- related incidents are present in some countries. The evaluation of such suspected poisonings shows that numbers of pesticide-related bee incidents are declining, e.g. in Germany and France. In others the occurrence of incidents in countries such as UK and Greece does not vary significantly from year to year.

### 2. Beekeeping practices

There are many different ways to keep and manage bees throughout the year; different programs are conducted in many countries worldwide to promote knowledge and to provide guidance on beekeeping practice adapted to the local needs. Beekeeping practices and the materials used, such as the type of hive, can be of high importance for the well-being of bees. To ensure efficacy some beekeeping and disease treatment practices may need adaptation according to different hive systems and equipment used. The diversity of different hive systems complicate the provision of general recommendations for bee keeping and especially Varroa treatment procedures, as minor modifications may cause major differences in effectiveness, and strengthens the need for further research and enforced advisory service.

### 3. Threats to bee health

A number of pests and diseases to which honey bees are susceptible, have been demonstrated as being implicated with colony losses. The major pests/diseases are *Varroa destructor*, American foulbrood, European foulbrood, *Nosema* spp., honey bee viruses, and Acarine mite *(Acarapis woodi)*.

In the past introduced parasites such as the Varroa mite have been particularly devastating to honey bees, therefore future threats and non-native invasive species are also of high interest, such as the Small Hive Beetle *(Aethina tumida)*, *Tropilaelaps* spp. (another parasitic mite) and the Asian Hornet *(Vespa velutina)*.

Varroa is present in virtually every colony in Europe. In the absence of treatments, colonies normally die, with a steep decline in the adult bee population until only a few bees and the queen remains. The mite is also an important vector of a number of viruses which affect honey bee health and shorten the lives of infected bees under certain conditions.

Varroa has irreversibly changed the Deformed Wing Virus (DWV) landscape across the world. Even when Varroa levels are controlled DWV can persist in the honeybee population at very high (almost 100% prevalence) levels and there is some evidence that it may be responsible for the increased overwintering colony losses reported and could potentially play a role in Colony Collapse Disorder.

DWV is now considered one of the key players in colony losses in Europe. Improved molecular techniques to detect multiple viruses will lead to improved understanding of their true distribution.

For the bacterial brood diseases, robbing by adult bees of contaminated honey sources, from weakened or dead colonies is an important mode of transmission between colonies. However, transmission from infected hives to healthy hives due to beekeeper practice is also a serious risk.

There are two species of Nosema affecting honey bees, both parasitic Microsporidian fungal pathogens. The only treatment for Nosema spp. has been fumagillin, but this is not registered across Europe, however, it may not be as effective at controlling infections of N. ceranae as N. apis.

There are currently no approved treatments for acarine disease. One option available to the beekeeper is to re-queen colonies that are susceptible to the disease. Generally the mite does not seem to be a major cause for concern in Europe, but North American beekeepers lost many thousands of colonies following the discovery of the mite there in 1984.

Currently both the small hive beetle and Tropilaelaps mites are believed to be absent from Europe. Introduction of either species would have the potential to cause major damage in certain parts of Europe.

When genetically similar colonies occur over wide areas, this may also increase the chances of disease transmission and loss of colonies. The existing subspecies and ecotypes of honey bees in Europe represent an important resource for breeding of disease and stress resistant strains. Anecdotal evidence suggests that locally adapted strains of bees suffer less from elevated losses.

### 4. Pesticides

Frequently the use of pesticides in agricultural cropping systems is discussed as a factor influencing bee health. Poisonings by spray applications have been reported in many countries. It is important to note that the most frequent causes of adverse effects of pesticides to bees are the misuse of products and/or ignorance of product label statements by farmers, combined with a poor communication with beekeepers, or disregard of good practices.

There does not appear to be any strong evidence that sublethal effects of pesticides play a key role as causative factors behind bee colony mortality. This is supported by the fact that in several monitoring projects no correlation has been found between colony losses and pesticide exposure. Still, further research on interactions of different stressors is recommended.

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 still contains some uncertainties regarding extrapolation to all conditions of use. Moreover, such monitoring approaches can reveal the necessity of stewardship measures for individual product types and provide valuable feedback on the effectiveness of implemented stewardship measures.

### 5. Economic factors influencing honey bee populations

Evidence also suggests that a drop in managed honey bee colonies in Europe may simply be linked to a decline in numbers of beekeepers and a reduction of the financial incentive. At the same time, honey prices have risen slowly whereas the price of materials and disease treatments have clearly increased and are relatively high discouraging people from pursuing beekeeping for profit. Fixed costs represent in certain cases up to 70% of the total costs, hence small scale beekeeping is often not economically viable. Among the variable costs, the highest share is taken by the costs incurred with the fight against pests and diseases.

A number of national programmes funding an improvement in the production and marketing of apiculture products have been fundamental in offsetting the loss of bees and should be maintained.

International organizations like FAO, OECD, and ICPPR have developed a series of activities to address issues related to Bee health. The European Commission, in addition to the focus they have put on biodiversity in their policies, has taken direct action to protect bee health by designating a European reference laboratory for bee health, co-funding national programs to support beekeeping and collect data on bee health as well as by revising their risk assessment procedures for pesticides.

## RECOMMENDATIONS

### COLONY LOSSES

- Due to the multi factorial nature behind the causes of colony loss (e.g. nutrition, disease, habitat, beekeeping practices, pesticides etc.) collaborative work between the various disciplines is necessary to resolve the issues.
- Existing networks involved in colony loss and the factors behind it need to be strengthened and made broader in scope.
- Priority should be given to investigations at the field scale to identify both the interactions between factors and success stories where progress has been made to improve bee health.
- Understand and measure the impact of colony losses on pollination services through the development of indicators such as impacts on crop yield and on native flora.

### TRENDS IN HONEY BEE POPULATIONS

- The number of honey bee colonies in EU countries is influence by economic factors and the attractiveness of beekeeping as a pastime or business. An analysis of the factors influencing the number of colonies in each country is necessary as trends vary between them.
- As pollination and hive products and bee health are important interrelated factors, an understanding of the commercial and pollination needs of each country is needed. This will enable for pollination services and the numbers of colonies per country to be maintained at a sustainable level and reduce the risk of crop loss and honey bee starvation.

### BEEKEEPING PRACTICES AND IMPACT ON BEES' WELFARE

- Focus on improved beekeeping practices and the implementation of risk mitigation practices, i.e. ensure that practices that have the most potential harm in practice to bee health and bee numbers are eliminated.
- Promote the communication and training of good beekeeping practices:
  - Colony care
  - Early identification of diseases and pests
  - Education of the utilization of honey bee food resources
  - Use of modern equipment
- Develop, promote and make available information portals (e.g. via the internet, smart phone apps etc) on beekeeping improvements, news and provide up to date information on key aspects of bee keeping including disease and pest control, weather warnings etc.

- Recommend programs co-financed by the EU to support the apiculture sector should be continued since they are focused on some key elements pointed out by this report, like the control of varroosis; improvement of beekeeping practices

## THREATS TO BEE HEALTH

### Pests and diseases

- Continue research on pathogens, diseases, pests and veterinary products.
- Promote faster mutual recognition of authorisations of bee medicines by a simple process of notification, which would make treatments for Varroa mite and other diseases more readily available to beekeepers across Europe.
- More research is needed to improve understanding on the true distribution and impact of honey bee viruses, their impact on bee health and possible countermeasures
- Non-native invasive species, including Small Hive Beetle, Tropilaelaps sp. and the Asian Hornet pose significant risks to European bee health and measures are needed to raise awareness, toprevent their introduction and spread within Europe and to develop contingency plans should they be introduced.

### Pesticides

- Continue research on pesticides, e.g. interactions of pesticides with other factors like pathogens, diseases, pests and veterinary products
- Continue to develop risk mitigation methods for the safe use of pesticides and include them in the conditions of use for the products.
- Education of pesticide users to understand the approved conditions of use and implement any mitigation measure necessary for the protection of bees.
- Promote the exchange of expertise in risk mitigation of pesticides between countries for example through the OECD PEIP portal.
- Continue to develop harmonized monitoring tools to clarify the impact of pesticides and other threats on honey bee health.

### Foraging habitat loss

- To counter the potential adverse impact of habitat loss, promote landscape management practices that are proven to be effective to promote bee health. This will also support the EU policies to preserve biodiversity in the agricultural landscape. This may be achieved through grower targeted subsidies.
- Efforts to improve pollinator and plant biodiversity, promotion and preservation of suitable habitats to ensure availability of flowers providing nectar and pollen throughout the season seem of high importance.

### Genetic diversity and resilience to pests and diseases

- Promote the research on the genetics of managed and feral honey bees to investigate the dynamic of disease and pest tolerance and promote the development of new strains of managed honey bees with improved disease and pest tolerance.

As a general recommendation we would like to point out the importance of improving communication to and between farmers and beekeepers and stress the need to better make available future research findings to institutions, to ensure beekeeping and farming continue to be successful and compatible, reducing bee losses and maintaining colony numbers, thus increasing honey bee contribution to pollinator services.

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