EIP-AGRI Focus Group

Bee health and sustainable beekeeping

STARTING PAPER

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1 Introduction

1.1 Scope of the Focus Group

Beekeeping and bee health: the situation today

Beekeeping as a profession or as a hobby is a growing interest today. The image of an ordinary beekeeper used to be an elderly man. That has now changed. A large number of both younger people and women have in the last decade started as beekeepers.

Beekeeping is a complex multi-stakeholder business. Bee colonies can be kept both in the rural and urban areas. The size of a beekeeping operation can vary from a few colonies to thousands. It can be stationary or migratory depending of the business direction and the surrounding landscape situation.

Honeybees used in beekeeping in Europe belong to the European honeybee species, *Apis mellifera* but of different races. Honeybees can fly and search for nectar and pollen in an area of 28 km^2 around the apiary. It means that they are under influence of the landscape where the apiary is situated. It is not up just to the beekeeper to manage the colonies in an appropriate manner, but also what other activities are taking place in the forage area. It all has effects on the health of the bees. While out foraging, bees pollinate the flowers at the same time, wild and cultivated ones, contributing to the pollination and resulting in better setting of fruits and seeds.

Depending on where in Europe the beekeeper is situated different issues concerning bee health and sustainable beekeeping arise. Compared to beekeeping fifty to sixty years ago, the beekeeper has to take care of the colonies in a much more conscious way. The saying that “whatever damage the beekeeper might have brought on the bees, they will fix it” is no longer true. Today the beekeeper needs to be much more educated and skilled to be able to help the honeybee colony to stay healthy and productive. Land managers also need to be aware of the impact of their activities on honeybee’s health, meaning becoming more educated and skilled in these subjects. Increasing problems are:

- bee diseases like varroa mite and the associated virus infections
- predators like the invasive species *Vespa velutina*
- lack of pollen diversity and nectar flow during the whole season, due to intensification of agriculture
- use of plant protection agents in flowering crops or in fields where bees are collecting water

Due to climate change, the situation adds more stressors to the colony, such as change of flowering for different plants, wet, dry, warm and cold periods in combination with established apicultural management practices. The beekeeper needs to stay alert for changes and being able to adopt new practices following the current situation at the very local level.

Regardless of whether one is a professional beekeeper or a hobby beekeeper the sector as a whole needs to advance the knowledge and innovation system, which means to:

- find standards of best practice
- have access to professional knowledge (theoretical and practical skills)
- make available education and work opportunities

This will force all actors involved to focus more on the quality of the services provided to the beekeepers and the farmers. Technical innovations, higher competence, societal demands and new technologies will put pressure on trainers and advisers to work more consciously with communication planning in the process of knowledge exchange. A holistic approach to stakeholders’ involvement, making the system self-driven and developed from within - and not dependent of the good will of other actors - can contribute to a better bee health and sustainable beekeeping.

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1.2 Objectives and tasks of the Focus Group

Sharing knowledge to inspire action

EIP-AGRI Focus Groups are temporary groups of selected 20 experts focusing on a specific subject. Experts are meeting twice and are:

- Sharing knowledge and innovative solutions
- Tackling questions from different angles
- Inspiring people to take action
- As an end-result, producing a recommendations and outcomes report

This discussion paper serves as background to prepare the first meeting of the EIP Focus Group on "Bee health and sustainable beekeeping" in May 2019. For this purpose, the document aims to:

- **Establish a common understanding** about the purpose and scope of the Focus Group.
- **Identify some preliminary issues and key questions for discussion** at the first Focus Group meeting.
- **Begin drawing together the available knowledge** on bee health and sustainable beekeeping, as a preliminary basis for the Focus Group final report.

Through the Focus Group process, we will review research evidence and practical experiences of bee health and sustainable beekeeping. The overarching QUESTION of the focus group is:

How to ensure the sustainability of beekeeping in the face of challenges linked to pests and diseases, intensification of agriculture and climate change?

The main question will be addressed through these specific tasks:

- Identify sustainable apicultural practices and tools to cope with challenges posed by climate change and to better control pest and diseases, including harmful invasive species (e.g. *Vespa velutina*).
- Identify sustainable agricultural practices (at plot, farm and landscape level) influencing beekeeping, including non-chemical alternatives for plant pest and disease prevention and control (i.e. preventive agronomic practices such as crop rotation and use of biological control).
- Harvest the existing knowledge on ways to monitor the effect of environmental and climatic conditions, beekeeping practices and agricultural practices on bee health and production.
- Identify remaining research needs from practice and propose possible directions for further research.
- Propose priorities for innovative actions by suggesting ideas for Operational Groups or other project formats to test solutions and opportunities and ways to exchange the practical knowledge gathered beyond the Focus Group.

Beekeeping as an occupation or hobby is in the most cases an environmental positive business. Through its impact as a pollination agent it has a high value to the agricultural landscape and ecosystem. **The scope of this focus group is however not to discuss the pollination issue.** The group concentrates on the factors having impact on the honeybee health and by that, finding key elements important to achieve a sustainable beekeeping.

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A *sustainable beekeeping* at farm level could be defined as "economical viable, socially acceptable and environmentally sound" (Kouchner et al. 2018)

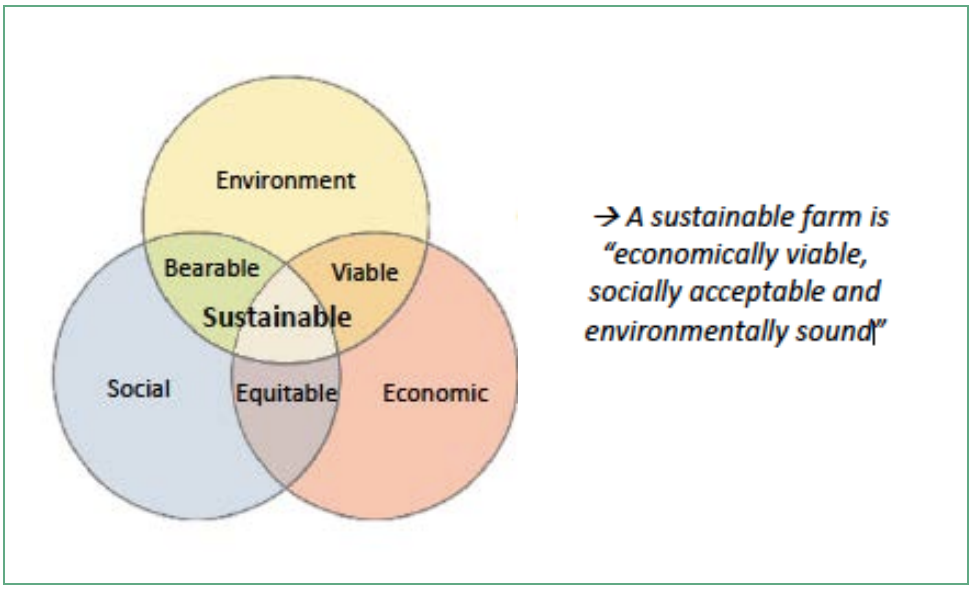

Figure 1: The three pillars of sustainability (Kouchner et al. 2018)

2 Main challenges for bee health and sustainable beekeeping

When alarms came in 2006 about honeybee colonies dying in large numbers in the US, it was an eye-opener also in Europe. Questions like where? how? and why? were posed. The initiative COLOSS (Prevention of honeybee colony losses) was formed as a COST Action activity[1]. COLOSS (**https://coloss.org**) is an international association focused on improving the well-being of bees at a global level.

The aim was to identify factors at the individual honeybee and colony levels causing severe colony losses and investigate synergistic effects between them. Some major focus areas (core project) were defined as for example:

- Monitoring colony losses
- Writing the 'Beebook' (standard methods defined for honeybee research)
- Bridging research and practice, B-RAP.

In addition, in order to deepen in some specific issues, COLOSS defined 8 specific task forces: 1) Varroa control; 2) Apitox; 3) Citizen Science Investigation, CSI Pollen (ended); 4) Sustainable bee breeding; 5) Small hive beetle; 6) *Vespa velutina;* 7) Viruses and 8) Survivors.

These focus areas and task forces give already an idea of the main challenges for bee health and beekeeping worldwide at the moment. Today, more than 10 years after, many of them keep threatening bee health and there are still many knowledge gaps to be filled.

[1] COST Action is a network dedicated to scientific collaboration, complementing national research funds **https://www.cost.eu**

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Are the main challenges the same for all beekeepers or are there differences?

Is it possible to assess the factors effecting bee health in relation to operation size (number of colonies) or management model (stationary vs. migratory)?

What is the influence of the land management and other beekeeping operations surrounding the honeybee colonies on bee health and its sustainability?

2.1 Honeybee diseases, pests and predators

The biology of the European honeybee is well known. Honeybees are social insects, meaning that no honeybees can live alone. Until a colony has a queen and several hundreds of workers it is not fully functional. A minimum number for a colony to survive, depending on the climate, is about 5.000 – 10.000 bees (Morse et al 1997). Colonies in the colder climates need more bees. Honeybee colony is regarded as a super organism, an organism consisting of several individual organisms that jointly make rational decisions. The offspring of a honeybee colony is the swarm.

To understand how diseases and parasites works in the bee colony it is necessary to regard the colony as one individual. Even though one single larva or adult bee can get sick, the pathogen has to adapt to the entire colony to succeed in making the host infected. A few dead larvae do not harm the colony, they are cleaned out by the bees and substituted by new healthy ones. But if the pathogen has the ability to infect many larvae it is a potential cause to weakening the colony so that it does not survive the winter. This has great importance to the epidemiology for the diseases (Fries et al 2008). To be vital and able to resist stressors like diseases, pests and predators the colony is dependent not only of its inherited properties (genetic expressions), but also of its surrounding environment and the beekeeping practices.

Diseases, pests and predators in the bee colony are relative few, compared to many other domestic animals. The following table lists the diseases, pest and predators of the honeybee colony

Bacteria	American foulbrood and European foulbrood
Viruses	e.g. Black Queen Cell Virus (BQCV), Chronic Bee Paralysis Virus (CBPV) and Sackbrood virus Viruses associated with varroa: e.g. Deformed wing virus (DWV) and Acute Bee Paralysis Virus (ABPV)
Fungi	Nosema (*N. apis* and *N. ceranae*) and chalkbrood
Mites	Varroa mite, tracheal mite and tropilaelaps mite
Insects	Small hive beetle, Asian hornet (*Vespa velutina*), wasps and hornets, wax moth, bee louse and ants
Birds	e.g. great tit, bee-eater and woodpecker
Mammals	e.g. bear, mouse and rat

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It should be noted that the distribution and incidence of these pests and diseases are not stable across Europe. For example, the predator Asian hornet (*V. velutina*) causes great damages and its impact is increasing year after year. It was confirmed for the first time in the South West of France in 2004. Since then, it has spread to Spain, Portugal, Italy, Germany, Belgium, UK and The Netherlands (see Figure 2). A constant pressure of hornet activity around a bee colony force the worker bees to defend the hive entrance, instead of spending time foraging. Pollen reserves becomes emptied, leading to mortality in developing bee larvae, weakening of the colony and potential colony loss. Even low levels of hornet numbers (fewer than 5 hornets/hive) can result in significant disruption.

In France, *honeybee* colonies predated by the hornet are typically left very weak, low in foragers or queen-less and vulnerable to disease and infestation and robbing. Adult hornets will enter weakened colonies, decimating brood and reserves (G. Marris 2011).

What are the factors – apart from available knowledge - that hinder the effective prevention and control of diseases, pests and predators?

2.2 Climate change

The European honeybee have great adaptability, as it is established almost everywhere in the world and in diverse climates. Bees adjust their behaviour to weather conditions. Locally adapted races work well with their surrounding environment. Change in climate means change in the periodic plant life cycle, called plant phenology, but will the bees and the beekeepers adapt to this? Will their bee phenology change according to the availability of pollen and nectar sources?

Honeybees will also need to adapt to predators, parasites and pathogens surrounding them. Not only will the relationships between bees and parasites change, honeybees might have to cope with new stressors coming from trade-facilitated transfers of pathogens among honeybee species. Furthermore, most pathogens have multiple strains with varying abilities to damage the host, which can be influenced by, among other factors, the environmental conditions.

Climate change therefore has the potential to change the host-pathogen dynamics, for better or worse, depending on the pathogen and the changes in the environment brought about by climate change. One example is varroa, whose reproductive success is lower in hot, dry climates, but who might benefit from a longer brood-producing season. Another is *Nosema ceranae*, which does not survive freezing very well and would benefit from milder winters, while *Nosema apis* is more adapted to colder climates.

Tropilaelaps mites have still not been detected in Europe. It is a parasite of brood only and it would not cause so much damage in European countries under the current climatic conditions. However, if climate change induces warmer winters and the honeybees would adapt towards a continual brood cycle, then it is a potential threat even in Europe. Warmer climate also stimulates the small hive beetle life cycle and the Asian hornet, meaning that they will extend their distribution range towards the northern parts of Europe. Models of climate change show an increase in the climatic suitability for the Asian hornet in the Northern hemisphere, especially close to the already invaded range in Europe, in Spain and in Central and Eastern Europe – from Switzerland to Hungary up to Southern Sweden (Barbet-Masson et al 2013).

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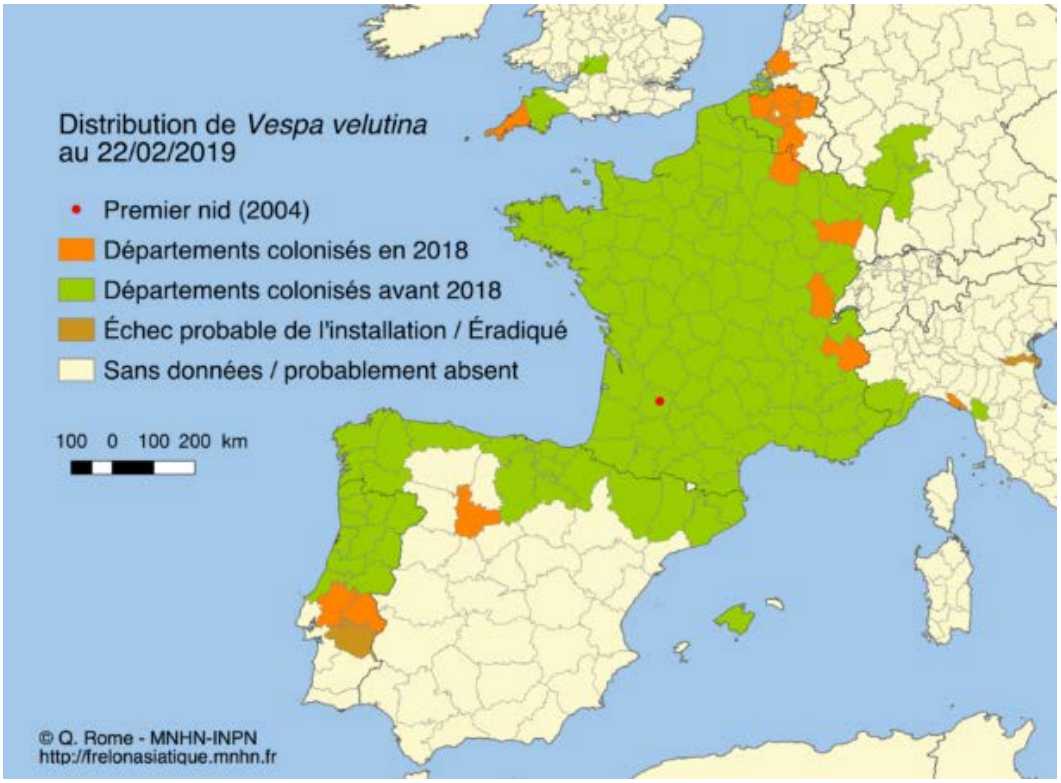

Figure 2: Map of distribution of the Asian hornet (*Vespa velutina*) in Europe, date 22/02/2019: In green, areas colonised before 2018. In orange, those colonised during 2018. Source **http://frelonasiatique.mnhn.fr/**

Climate change can also have a direct influence on honeybee behaviour and physiology. It can alter the quality of the floral environment and increase or reduce colony development and production capacity.

The honeydew produced by sucking insects from certain plant species is also climate-dependent. Certain types of honeydew can cause dysentery in honey bees or give a rock-hard honey called cement honey.

Honeybees that are born in late summer/autumn spend the winter in the hive and form the basis of the colony in spring. A pollen diet is very important for rearing healthy winter bees. A pollen shortage induced by autumn drought will have the effect to reduce the bees surviving possibilities in winter such as weakening their immune system and making them more susceptible to pathogens and shortening their lifespan (Le Conte et al 2008).

It can therefore be necessary for beekeepers to change their apiculture methods. They might need to change their migration habits and abandon areas that have become too dry in favour of wetter areas. They will consider importing races from other areas to test their potential to adapt to new climatic conditions, which in turn increases the risk for introduction of new pathogens.

What will be the impact of climate change on honeybees, their plant environment and their diseases?

Is the existing genetic variability of honeybees crucial for adaptation to new conditions?

Is trade in honeybees a factor of diversity and environmental adaptability?

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2.3 Sustainable agronomic and forestry practices

Modern agricultural systems are aiming at high yield and profitability. This have led to large-scale farming with monoculture, inorganic fertilisers, chemical pest control and hybrid plants. Each element provides its individual contribution to productivity, but when they are all combined in a farming system, each depends on and reinforces the need for using the others.

The main threats to honeybees in the agricultural landscape are:

- Plant protections products
- Monoculture without agri-environmental measures, like flower strips or other similar measures during the whole season
- Lack of nectar and pollen during the whole season

Use of plant protection products influences the health of honeybees, and even if a product is classified as non-hazardous to bees, it can pose a risk to them. A product may even spread more widely than intended, either through negligence or unintentional dispersion via wind and water. The results from sampling tests show that residues of plant protection products are sometimes found in surface water and groundwater, and honeybees collect water for the colony (MUST-B project, EFSA2).

The health of the honeybees is also very much depending on the floral landscape they are situated in. And the configuration of this landscape can partly be explained by the ratio of forest vs farmland, the farming structure (size of the farms mainly) and by the management of the land, like Ecological Focus Areas (EFAs) with benefits for pollinators such as hedges and trees and flowering buffer strips[3].

Farmland covers 47% of the land area in EU and forests cover 38% but the forest coverage varies considerably from one member state to another; while forests in Finland, Sweden and Slovenia cover more than 60% of the country, whereas it is only 11% in the Netherlands and the United Kingdom. There are large differences between countries even regarding agricultural areas, in Ireland and the United Kingdom it is 75–70%, in Sweden and Finland it is only 7,5% (Eurostat). Independent of if the bee colonies are situated in the farmland or in the forest, they are always dependent on continues sources of pollen and nectar. At the border between farmland and forest one usually finds flowering plants.

There are also big differences in the structure of agriculture across the EU. A large number of small farms (less than 2 ha) is using just a small proportion of the total land area (2,5%), and a small number of very large farms (over 100 ha) is using 50% of the utilised agricultural area. The picture varies across Europe and for example Romania is the country with the largest number of small farms (less than 2 ha). In Belgium, Germany, Denmark and France the majority of farms are larger than 20 ha (Farm Structure Survey 2013). The small farms, as they favour a more heterogenous landscape, provide a higher number of elements positively contributing to increased bee resilience.

[2] MUST-B project (EFSA) https://www.efsa.europa.eu/en/topics/topic/bee-health
[3] Focus Group Optimising profitability of crop production through Ecological Focus Areas https://ec.europa.eu/eip/agriculture/en/focus-groups/optimising-profitability-crop-production-through

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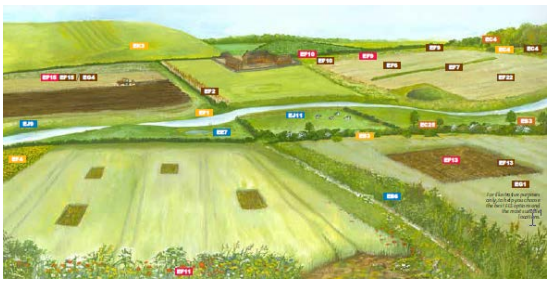
Agricultural and forest practices threatening currently bees are expected to change in the next decades. Public subsidies within farming have for a number of years indirectly promoted large-scale farming but are now changing towards more sustainable farming methods and environmental measures. In fact, the Common Agricultural Policy (CAP) has identified three priority areas for action to protect and enhance the EU's rural heritage:

- biodiversity and the preservation and development of natural farming and forestry systems, and traditional agricultural landscapes
- water management and use
- dealing with climate change

Adopting farming practices in field crops that are conducive to the survival of bees and other pollinators can benefit both the grower and the beekeeper.

Communication and cooperation between beekeepers, farmers and their advisors are the most effective way to protect the bee health. When growers and beekeepers are aware of each other's locations, concerns and management practices they can avoid causing exposure to pesticides to honeybee colonies and foraging bees.



Farmers and beekeepers hand by hand

The publication **"Farming for farm wildlife"** compiles a set of good practices that farmers can adopt to favour wildlife on their areas, including good practices benefiting bees and other pollinators.

The document explains not only how to promote the wildlife in farmlands but also which are the gains for the farmers.

By taking certain actions within large scale farms the environment for bees could very much be improved (The Honey Bee Health Coalition 2019). For example, some measures that can be taken are:

- Maintain an open line of communication with nearby beekeepers and local beekeeping associations
- Scout fields to determine whether a pesticide application is needed
- Choose insecticides with low and/or short residual toxicity to bees
- Follow label instructions every time a pesticide is used
- Choose to make foliar application within two hours of sunrise or sunset
- Follow best practices to manage drift
- Consider avoiding tank mixing of insecticides during fungicide or herbicide application (growers or applicators use tank mixing to save money on fuel and labour, as it reduces the number of applications through a field by applying treatments at once)
- Improve foraging areas for bees and other pollinators, e.g. flower strips

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So, at the end, what do honeybees need in their surrounding?

- Nectar and pollen plants continuously during the season
- Fresh water
- A dry and well protected area (low moist and wind conditions)
- Ultimately, forest and open fields at the same time
- Free from predators
- No ground vibrations

How is the farm landscape structure in your country?

How is coordination with other actors in the forage area managed?

2.4 Other stressors

Stressors to honeybees are usually a result of multiple causes. Apart from the above-mentioned stressors, we can also consider:

a) inappropriate management in beekeeping

b) low profitability within beekeeping[4]

c) the increasing competition between honeybees and wild pollinators

d) migration due to lack of places for permanent apiaries

e) neighbouring beekeepers not controlling varroa

f) availability of mating sites for queens for appropriate genetics

[4] Low profitability can be considered a stressor if the beekeeper doesn't get paid for all measures needed for keeping bees healthy.

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2.5 Beekeeping from colony to landscape

Compared to other domestic animals, honeybee health depends on the environment and the beekeeping practices at many different levels. In general, and particularly when talking about honeybee health, we can differentiate four levels of action: a) colony (hive) level; b) apiary level; c) beekeeping operation (beekeeper management) level; and d) landscape level.

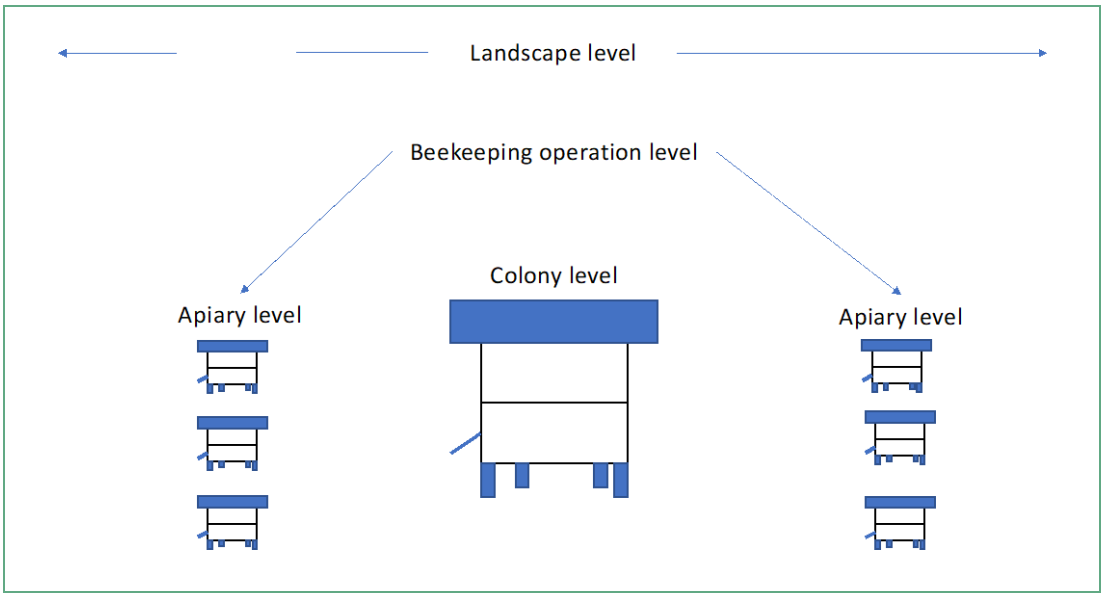

Figure 3: Overview of the different management levels in beekeeping

Depending on the scale, stressors affecting bees are different. These are some of the threats beekeeper should consider at each level:

- Colony level: (in-hive stressors) e.g. pathogens, poorly mated queens, bees not adapted to local conditions and inappropriate management
- Apiary level: (in-apiary stressors) e.g. robbery, re-infestation of varroa, transfer of brood or food frames between colonies
- Beekeeping operation level: (within beekeeping operational level stressors) e.g. transfer of beekeeping equipment and tools, transfer of brood or food frames between colonies
- Landscape level stressors: e.g. broken supply of high-quality diet, lack of propolis, lack of water, exposure to plant protection chemicals, poorly coordinated land management measures (logging of forest, blasting, spraying of crops) and food competition from other beekeeper's colonies

The impact on bee health at many levels makes the challenges complex and multi stakeholder approaches necessary.

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3 Beekeeping management methods, some examples

3.1 Good beekeeping management practices

Every beekeeper should seek to have bee colonies that are healthy and productive. That is a basic rule. If you are a beekeeper, you are responsible for your honeybees. They are domestic animals and need to be taken care of.

What are the Good Beekeeping Management Practices?

A practice, or a combination of practices, that is determined to be an effective and practical means of improving honeybee health and reducing risks to colonies. Good Beekeeping Management could be specific steps and actions that beekeepers, managing at any scale from one single colony to commercial apiaries, can take to protect their bees (see references for examples).

There are many publications about how to best manage the honeybee colonies for good health. A wide range of both public and private organisations have developed Good Beekeeping Management Practices for the honeybee industry. They all contain some basic information about the importance of:

- Education
- Existing laws and regulations
- Apiary and hive maintenance
- Minimising risks from pesticides
- Varroa control
- Management of other pests and diseases
- Queen health, new colonies and honeybee breeding
- Honeybee nutrition

3.2 Prevention and control of bee diseases

Already mentioned in the definition of the Good Beekeeping Management Practices, one important factor is to control bee diseases. The best way is to prevent them, following the saying “better to prevent than cure”. And as explained previously, the distribution of diseases worldwide is in continuous change. One of the recent diseases in Europe is the small hive beetle which was found in the southwest of Italy in 2014. Up to now, the tropilaelaps mite is the only parasite we know of on honeybees not yet discovered in the EU.

All diseases have their own way of interaction with the honeybees, more or less harmful to the colony but there is some recommendation on how to help the honeybees to stay fit in general:

- Keep strong bee colonies
- Have young and locally adapted queens
- Secure pollen and nectar sources during the whole season

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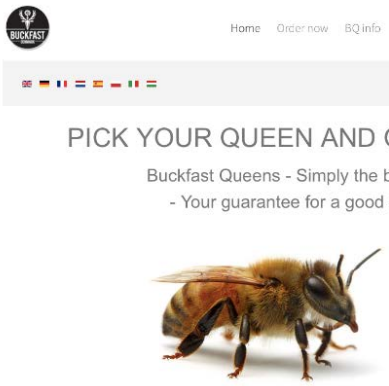
- Ensure enough food for winter
- Use appropriate and clean beekeeping equipment
- Make frequent wax renewal
- Monitor the varroa situation and treat accordingly

3.3 Bee breeding

The most common subspecies of the European honeybee, *Apis mellifera* in Europe are:

A. m. ligustica (Italian bee)
A. m. carnica (Carniolan bee)
A. m. mellifera (The dark bee)
The crossbreed Buckfast bee

Meeting the demand for high economic performance, selective breeding for traits of commercial interest focuses on Buckfast, *A.m. ligustica* and *A.m. carnica*. Commercial production of queens, migratory beekeeping and a free market permitting the trade of honey bees with no limitations on genetic origin, are factors endangering native honey bee populations. The 12 subspecies of honeybees native to Europe have, in many places, been replaced by non-native bees. The conclusions from the comprehensive field experiment, the GEI Experiment (Pan-European **G**enotype-**E**nvironment-**I**nteractions Experiment) tend to confirm higher vitality of the local bees compared to the non- local ones. This indicates that a more sustainable beekeeping is possible by using and breeding bees from the local populations (Meixner et al 2014).



Easy access to honeybee queens, just order on the internet: Some beekeepers believe that queens purchased from outside their own region are "better" than the bees they already have in their own hives.

3.4 Honeybee nutrition

Honeybees need protein and carbohydrates. They get the protein from pollen and carbohydrates from nectar or honeydew. To store nectar or honeydew, bees transform it to honey and to store pollen they make a lactic acid bacteria fermentation of pollen producing beebread. Pollen from different plants have different nutritive values. Brodschneider et al (2010) divide the demands of nutrition in three levels, colony nutrition, adult nutrition and larval nutrition. Larvae are especially dependant on protein and brood production is strongly affected by shortage of this. If there are no strong healthy larvae, there is no strong healthy colony.

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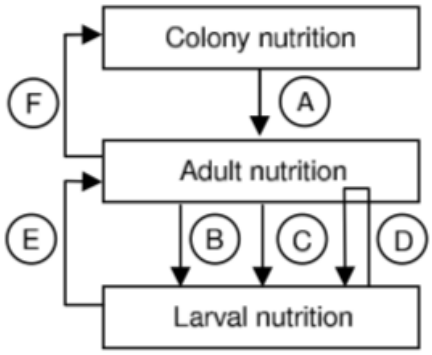
Honeybees often occur within a human-defined ecosystem and bees' nutritional needs may not be provided for. Poor colony pollen stores may hinder adult honeybees from feeding larvae properly. If lack of pollen, the bees can cannibalize brood to access protein to feed other larvae.

Then, in late summer, the last generation of bees produced shows a markedly increased lifespan compared to the short-lived summer bees. Colonies terminate brood rearing rather than produce malnourished pupae. If reared, the bees have an impaired quality. Finally, nutrition-related risks to honeybee colonies include starvation due to monocultures and pesticide residues in pollen and nectar may have lethal or sublethal effects on honeybees.



A: dependency of adults on colony food stores
B: investment in larval quality
C: regulation of larval number
D: cannibalism
E: impact of larval nutrition on next adult generation
F: impact of adults on colony nutrition

Figure 4: A schematic representation of the three levels of honeybee nutrition, dependencies, and possible effects of protein malnutrition (Brodschneider et al 2010)

3.5 Migratory beekeeping for honey production and pollination

Following the crops in need of pollination or crops that are good for honey production through Europe, is one way of making the beekeeping more profitable. When for example the oilseed rape start blooming in early spring in the south of Europe the migratory beekeeping (moving of bee colonies) follows the blooming oilseed rape to the northern parts.

Studies show that travelling bees have generally shorter life than stationary bees. Travelling bees have also greater oxidative stress levels – which ages them more quickly and may lessen their capacity to fight off disease and parasites (M. Simone-Finstrom et al 2016). The study found that migratory beekeeping influences the lifespan of bees, but how this impacts health and honeybee aging is more complicated and often more influenced by the environment these colonies are in.

3.6 Monitoring colony and landscape

By technically monitoring the bee colony, beekeeper might get information about necessary management to be done. Changes in activities within the hive will indicate early signs of potential swarming or poor health. Measures like that could increase the efficiency of beekeeping by predicting behaviour that requires intervention from a distance. By keeping records of the status of the colonies and what actions taken the beekeeping can be improved from year to year. A holistic approach and earned knowledge give experience and develops the skills resulting in better bee health.

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Monitoring the landscape is dependent on communication between growers and beekeepers. The need to identify bee colonies in the area were pesticides are being used is crucial to avoid poisoning. In North America the website **DriftWatch** exist to view the location of registered bee hives. And, as beekeeper, you would like to know more about the land use around the apiaries, what crops are being grown and what pesticide applications occurs. The website **CropScape** (USDA) or registries such as **FieldWatch** and **Beescape** exists for that purpose.

There are no regulations controlling virus in honeybees, is this a threat to honeybee health?

It takes a good queen to make a good colony. Desired characteristics are hardiness, low swarming, gentleness, ease of handling, resistance to disease and honey gathering ability. How should a sustainable breeding program look like?

How important are monitoring on colony and landscape level for bee health?

4 Beekeeping knowledge and innovation system

Knowledge exchange and development, for and with the beekeepers, has become a key element in the implementation of measures to decrease winter losses and improved bee health. One approach to this issue is to create a bridge between best available knowledge and existing beekeeping practices in a Knowledge and Innovation System supporting beekeeping (B-KIS).

Advisory services particularly can play a key role in it. Capacity building must be based on up-to-date situation reports like monitoring results. Furthermore it should be demand-oriented and the objectives and methods vary in terms of the environment and dimension (individual, organisational or institutional). Capacity building is about liberating pre-existing potentials.

4.1 Behavioural change

The researchers, extensionists and the advisors in beekeeping know quite well what factors are having the most influence on bee health. If the beekeeper follows these advices the goal of a sustainable beekeeping with good bee health can be achieved. But today it is hard to reach out with evidence based knowledge in the flow of information available to beekeepers. So if we really want to change behaviours, we need to do more than just provide beekeepers with scientific information. We need to be strategic in how we use communications to help achieve better bee health. And the forms of communication are changing. New tools are developed and combined in innovative ways. Knowing what to do when and why is the core competence in strategic communication.

From a communications perspective raising awareness is just one step on the path to changing behaviour. Aiming to reach a sustainable beekeeping is all about doing thing differently. More of the same is not enough. Sustainable apiculture needs sustainable extension and advisory services.

In strategic communications the aim is to communicate the most relevant messages, through the right channels, measured against well considered communications-specific goals, and with a good understanding of the target group. *It is not only about communicating; it is doing the right communications that create change.*

- New methods of outreach: There are now many more avenues available to reach the beekeepers. Digitalisation and increased demand for participation push this development today

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- Consistency: There is a greater need for consistency between the actors involved in communication to a specific target group, since the beekeepers easily can Google anything online
- Coordination: The same communication channels (e.g., Facebook) are useful for education, networking, fundraising, etc, and as an advisor or extensionist one needs to strike a balance between getting out important messages and also attracting readers. To attract an interest through traditional channels has never been as hard as it is today
- More professionalism: Also, there is a problem of amateurs, although claiming to be 'experts', attract too much interest. Desktop publishing allows anyone with a PC to make a newsletter or magazine

There is an obvious risk that the internet de-professionalise communications. Professional trainers, educators, extensionists and advisors need to meet these challenges in a partly new way (Ljung 2018).

4.2 The Beekeeper Stewardship concept

The definition of stewardship in this paper means the careful and responsible management of something entrusted to one's care, stewardship of honeybees.

In a beekeeper survey (U.S. national survey of beekeepers, 2018) questions about what a good stewardship for honeybees are, were asked. The dominant attitudes were keeping bees healthy, minimizing disturbance, and monitoring hives.

The survey found that those who say that stewardship means bees should not be disturbed or subjected to chemicals and should be given forage to do their 'normal business' belonged to the group that was less likely to treat for Varroa. The group that is more likely to treat for Varroa identify themselves as bee stewards and say stewardship means active hive management and keeping bees healthy and alive.

Stressing the importance of the beekeeper stewardship is essential for a socioecological understanding of how to address challenging Varroa management and complex human– environmental production systems that have landscape level effects (Thoms et al 2018).

How can strategic communications be used as a tool to help achieve a better bee health and a sustainable beekeeping?

How can collaboration among stakeholders improve bee health and sustainable beekeeping?

What is a good stewardship for honeybees?

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A mechanistic model to assess risks to honeybee colonies from exposure to pesticides under different scenarios of combined stressors and factors. MUST-B project, EFSA supporting publication 2016.

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Best Management Practices (BMPS) for pollinator protection in canola fields: Honey bee health coalition 2019

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Migratory management and environmental conditions affect lifespan and oxidative stress in honeybees: M. Simone-Finstrom, H. Li-Byarlay, M.h. Huang, M. K. Strand, O. Rueppell and D.R. Tarpy 2016

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Communication for Rural Innovation, thinking agricultural extension; C. Leeuwis 2004

Smartbees WP 5: Final report M. Ljung 2018

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Annex II: Websites

1. Good Beekeeping Practices

https://ec.europa.eu/food/sites/food/files/animals/docs/la_bees_research_manual_bee_keepers_en.pdf

https://honeybeehealthcoalition.org/hivehealthbmps/

https://honeycouncil.ca/wp-content/uploads/2016/12/BMP-manual-for-honey-bee-health-Feb-2017-English.pdf

https://honeybee.org.au/pdf/NBPFBIAE.pdf

https://articles.extension.org/pages/33379/best-management-practices-for-beekeepers-and-growers

http://edis.ifas.ufl.edu/pdffiles/IN/IN87400.pdf

http://bonnes-pratiques.itsap.asso.fr

https://conapi.it/wp-content/uploads/2016/12/manuale-delle-buone-pratiche-apistiche.pdf

http://servagri.eu/attachments/article/227/Vademecum_apicoltura.pdf

http://www.parks.it/parco.beigua/PDF/Manuale.Buone.Pratiche.Apicoltura.pdf

http://www.mieldemalaga.com/data/manual_buenas_practicas_apicultura.cl.pdf

2. Beekeeping projects

EU beekeeping projects
https://ec.europa.eu/food/animals/live_animals/bees/research_en

Poshbee
http://poshbee.eu

Smartbees
http://www.smartbees-fp7.eu

COLOSS GEI-experiment
https://coloss.org/accomplishments/the-gei-experiment/

EPILOBEE
https://ec.europa.eu/food/animals/live_animals/bees/study_on_mortality_en

The Asian hornet
https://coloss.org/task-forces/velutina/
http://frelonasiatique.mnhn.fr

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3. Agriculture

www.europarl.europa.eu/factsheets/en/home

https://ec.europa.eu/info/events/2018-eu-agricultural-outlook-conference-2018-dec-06_en

https://ec.europa.eu/eurostat/statisticsexplained/index.php/Farm_structure_survey_2013_-_main_results

ec.europa.eu/agriculture/index_en.htm

https://www.gov.uk/government/organisations/natural-england

https://driftwatch.org

https://nassgeodata.gmu.edu/CropScape/

https://fieldwatch.com

4. Honeybee health

https://www.efsa.europa.eu/en/topics/topic/bee-health

http://www.oie.int/en/animal-health-in-the-world/animal-diseases/diseases-of-bees/

https://honeybeehealthcoalition.org/wp-content/uploads/2016/07/Bee-Healthy-Roadmap-October-2014.pdf

www.coloss.org

5. Technical solutions for monitoring bee colonies

https://www.arnia.co.uk

https://nectar.buzz

https://pollenity.com

https://apistech.eu/en/

http://worldbeeproject.org/world-bee-project-hive-network

http://www.honeyflowafrica.com

https://www.osbeehives.com

http://colonymonitoring.com/cmwp/for-entrepreneurs/

https://beecombplex.com

https://www.apisprotect.com/home

https://www.t-systems.com/en/best-practice/02-2018/focus/bee-and-me/smart-beehives-810982

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https://www.label-abeille.org/gb/

https://www.keltronixinc.com

https://hivemind.co.nz

https://hostabee-site.firebaseapp.com

http://beeandmegmbh.com

https://www.3bee.it/en/about-us/

https://broodminder.com

https://www.f6s.com/apiarybook

http://www.iris-tech.tn/en/

https://beescanning.com

https://pollenity.com

https://cordis.europa.eu/project/rcn/105847/factsheet/es

6. B-KIS

www.bee-extension.org

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