Food and Agriculture Organization of the United Nations

ISSN 1810-0708

# Responsible use of antimicrobials in beekeeping

FAO ANIMAL PRODUCTION AND HEALTH / **GUIDELINES 26**

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# Responsible use of antimicrobials in beekeeping

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Food and Agriculture Organization of the United Nations
Rome, 2021

**Required citation:**
**FAO and IZSLT.** 2021. *Responsible use of antimicrobials in beekeeping*. FAO Animal Production and Health Guidelines No. 26. Rome, FAO. https://doi.org/10.4060/cb6918en



ISBN 978-92-5-135005-8


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# Foreword

Honeybees are fundamental to life on Earth in terms of their contribution to environmental biodiversity and quantity and quality of agricultural production systems. The absence of honeybees for pollination could mean a loss to farmers of up to 75 percent of their crops. Moreover, hive products themselves (honey, pollen, royal jelly, wax, propolis and bee venom) generate income for beekeepers and are an important source of food and energy for human consumption all over the world, and especially in rural areas.

Honeybees face numerous health threats, including loss of habitat due to land-use changes, diseases and pests, poor management practices, indiscriminate use of veterinary medicines and pesticides, climate change, the spread of monocultures which reduce their food variety, and the spread of honeybee pathogens due to globalization.

Healthy honeybee populations are important for the achievement of several of the United Nations Sustainable Development Goals (SDGs): "No poverty" (SDG1); "Zero hunger" (SDG2); "Good health and well-being" (SDG3); "Gender equality" (SDG 5); "Decent work and economic growth" (SDG8); "Responsible consumption and production" (SDG12); "Climate action" (SDG 13), and "Life on land" (SDG15).

The World Organisation for Animal Health (OIE) classifies honeybees as terrestrial animals, which means that they require veterinary care.

The increase in honeybee colony losses seen in some areas of the world and the emergence of new diseases threaten the pollination services and environmental biodiversity provided by honeybees, and the beekeeping economy itself. In this context, a qualified diagnostic approach and proper use of antimicrobials at the apiary level is of fundamental importance to avoid unwanted effects such as residues in honeybee products and antimicrobial resistance (AMR).

Honeybee diseases, their prevention and control fall within the scope of veterinary medicine.

To guarantee honeybee health, veterinarians should work in close cooperation with livestock production experts and specific measures should be put in place: 1) enforced legislation on the proper use and control of antimicrobials (prescription, distribution, administration, withdrawal time, residues, etc.) and related controls; 2) enforced legislation on the transboundary and local movement of live bees and genetic material; 3) training on good beekeeping practices and proper biosafety measures; 4) introduction of technical certifications for all those intending to keep and manage bees; implementation of sustainable beekeeping models to properly safeguard the health of bees and consumers and to protect the environment; 5) regulation and monitoring farmer–beekeeper interactions to prevent colony losses due to misuse of pesticides; 6) proper training of veterinarians on bee diseases; 7) coordination of all beekeepers operating in the same area concerning timing of intervention, type of treatment (e.g. varroacide) to apply and other relevant measures.

Veterinarians have a responsibility to maintain a working relationship with beekeepers to support honeybee disease prevention and containment efforts. With the application, at the apiary level, of good beekeeping practices (GBPs) and proper biosecurity measures in beekeeping (BMBs), honeybee diseases can be prevented, and the use of unnecessary medicines reduced. These guidelines focus on preclinical indicators as an essential part of GBPs, which enable diagnosis of bee diseases before clinical signs appear in the colony. They also underline the importance of adopting a sustainable approach in apiary management, which includes the use of medicines with a low environmental impact and avoidance of antibiotics. The latter can quite easily be achieved with specific beekeeping techniques and integrated control of honeybee diseases. Organic honey and bee products tend to fetch a higher price on the market and be more profitable, even though this kind of bee management is more labour-intensive and needs greater control. The emphasis here should therefore be on promoting and asserting quality as opposed to quantity.

Sustainability is key to the future of beekeeping, and the One Health approach which considers human, animal and environmental health interconnected, ensuring high-quality hive products free of medicinal or pesticidal residues and adulteration.

These guidelines define and categorize GBPs and BMBs that can minimize use of antimicrobials at the apiary level, reducing the risk of residues in honeybee products and limiting AMR. It also introduces the Progressive Management Pathway for Biosecurity Measure in Beekeeping (PMP-BMB), a useful tool to assist governments, beekeepers and the industry in defining the steps required for sustainable, healthy and resilient beekeeping.

Finally, we provide three different surveys (on Varroa management, infectious disease management and AMR) which may be useful for countries and beekeepers wanting to adopt a PMP approach, enabling them to assess their current performance concerning the application of GBPs and BMBs and antimicrobial use in beekeeping.

A PMP approach, GBPs and BMBs are all conducive to proper honeybee management, which in turn: 1) ensures better honeybee health, 2) ensures better human health, 3) protects the environment, and 4) increases the profitability of the beekeeping sector in a sustainable context.

# Acknowledgements

The editors would like to thank Dr Berhe G. Tekola (FAO) and the guidance provided by Dr Juan Lubroth (FAO).

The following members of the FAO Antimicrobial Resistance (AMR) Working Group contributed to the development of the Progressive Management Pathways approach in beekeeping: Koen Mintiens, April Johnson, Alice Green, Jeffrey LeJeune, Jieun Kim and Jing Xu.

Moreover, the editors would like to thank the BPractices consortium partners[1], Sofia Croppi (Hartpury University), Alejandro Dorado García (FAO–NSAH), Francesca Latronico (FAO), Franco Mutinelli (IZSVe), Jeff Pettis (Apimondia), Marco Pietropaoli (IZSLT), Marc Schäfer (OIE Collaborating Centre for Varroa, SHB [small hive beetle] and AFB [American foulbrood]), Joseph Cazier (Appalachian State University), and Beate Scherf (FAO), for their input.

[1] The BPractices project consortium is made of a multidisciplinary group representing research institutes, the Food and Agriculture Organization of the United Nations (FAO) and the International Federation of Beekeepers' Associations (Apimondia). https://www.izslt.it/bpractices/

# Executive summary

Honeybees are indispensable pollinators for crop production and maintenance of biodiversity.

These guidelines aim for sustainable management of honeybee health in modern beekeeping with responsible use of antimicrobials, following the One Health approach to safeguard not only bee health, but also human health and that of the environment. To this end, disease prevention is preferred to treatment, as the latter often involves extensive pharmaceutical intervention. Use of medicines can be avoided by implementing good beekeeping practices (GBPs) and biosecurity measures in beekeeping (BMBs), to maintain colony health and reduce the likelihood of antimicrobial residues in hive products.

If antimicrobial is necessary, it is advisable to choose medicines with a low environmental impact, using them prudently and following the instructions provided.

It is imperative to use the correct pharmaceutical (authorized in the country of use and ideally prescribed by a veterinarian) and avoid antibiotics as much as possible.

In terms of the One Health approach, prudent and limited use of antimicrobials benefits the quality of bee products and the safety of surrounding ecosystems, while also slowing development of antimicrobial resistance (AMR), which is a widespread issue affecting multiple sectors.

Honeybees can contract a variety of infectious diseases (e.g. varroosis, nosemosis, American foulbrood, European foulbrood, etc.) which pose differing levels of risk to colony health and should be managed accordingly. For each disease listed, these guidelines provide an explanation of early disease detection, a list of preventive measures and if needed, available treatment options.

To further aid beekeepers in implementing these practices and achieving sustainable production, a progressive management pathway (PMP) has been devised, focusing on BMBs and proper use of antimicrobials. It has been broken down into four Focus Areas to help beekeepers and policymakers/design teams set achievable goals in order to eventually reach full sustainability. To facilitate initiation of this PMP, surveys were created to assess current beekeeping practices/BMBs and general awareness of topical issues such as AMR.

The overall aim of these guidelines is to inform beekeepers of current challenges within the sector and help them bring about sustainable production and maintain colony health.

Chapter 1

# A global overview of the beekeeping sector

Beekeeping plays an important role in generating employment opportunities and increasing family income in rural areas of the world. Figure 1 presents the number of hives managed all over the world from 2007 to 2017.

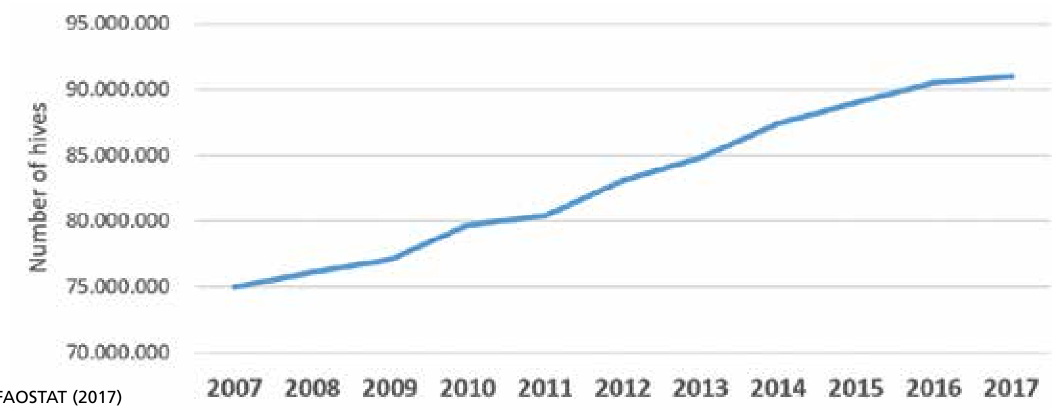
The global trend of kept honeybee populations in the last decade has increased, with an estimated 74,967,203 hives in 2007, and an estimated 90,999,730 in 2017 (a 21.4 percent increase).

Analysis of the distribution of the honeybee population across different geographic areas shows that this increase has predominantly occurred in Asia (see Figure 2).

Of the top nine honey-producing countries, which account for almost 60 percent of global production, China ranks first with 543,000 tons, followed by Turkey, Argentina, the Islamic Republic of Iran and the United States of America (see Figure 3 and Table 1).

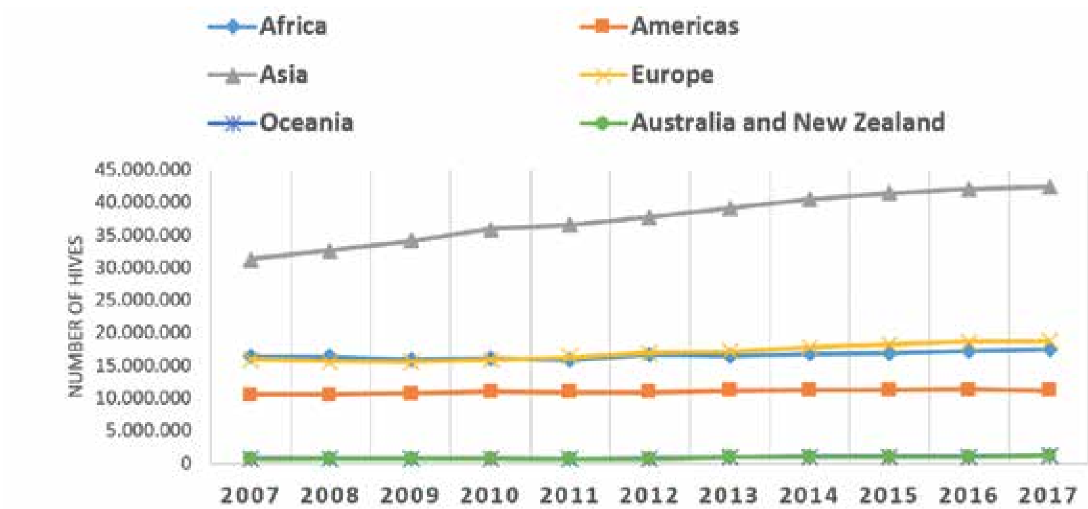
The tons of honey produced by continent are shown in Figure 4.

FIGURE 1
**Managed world honeybee populations (2007–2017)**




*Source:* FAOSTAT (2017)

FIGURE 2
**Managed world honeybee populations, by geographic area (2027–2017)**



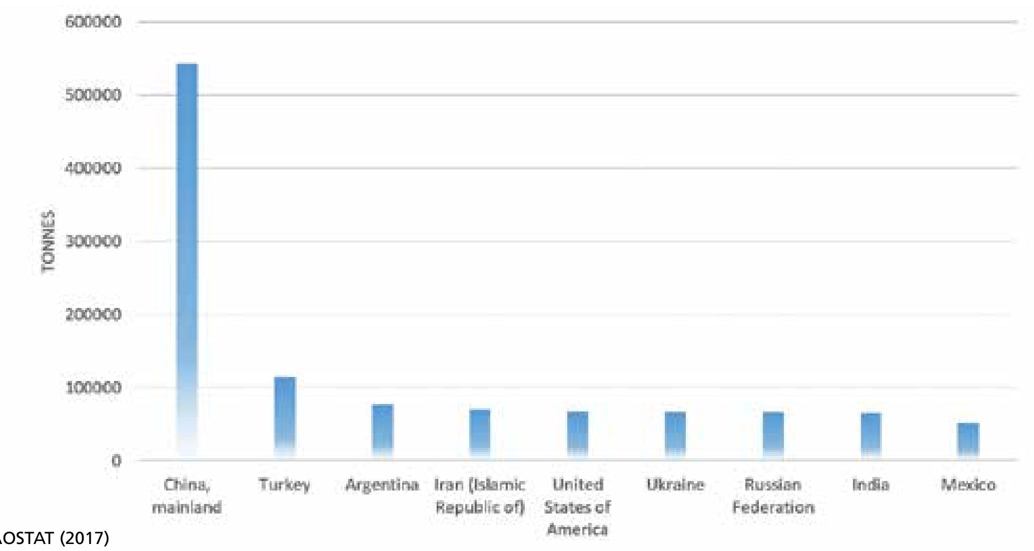

*Source:* FAOSTAT (2017)

TABLE 1
**Top nine honey-producing countries (2007–2017)**

| Country | Tons |
|---|---|
| China, mainland | 543,000 |
| Turkey | 114,471 |
| Argentina | 76,379 |
| Iran (Islamic Republic of) | 69,699 |
| United States of America | 66,968 |
| Ukraine | 66,231 |
| Russian Federation | 65,678 |
| India | 64,981 |
| Mexico | 51,066 |

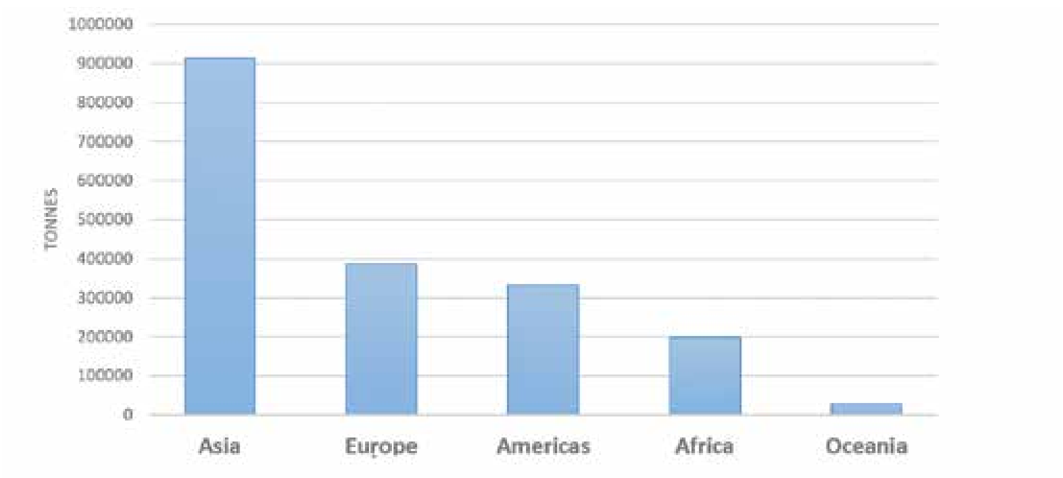
*Source:* FAOSTAT (2017)

FIGURE 3
**Top nine honey-producing countries (2007–2017)**




*Source:* FAOSTAT (2017)

FIGURE 4
**Top nine honey-producing continents (2007–2017)**




*Source:* FAOSTAT (2017)

# Chapter 2
# Prevention is better than cure

Good beekeeping practices (GBPs) and biosecurity measures in beekeeping (BMBs) can prevent honeybee diseases. Healthy hives are key to optimal productivity and, therefore, profitability. Moreover, they reduce use of antimicrobials, which also includes the cost of purchasing them and the time required to apply them.

Risk assessment is a valuable tool and provides tailored animal health measures based on local disease management practices and use of antimicrobials. To see how many GBPs and BMBs are applied in your apiary, complete the risk assessment surveys in Annex 3.

Regular consultation with a veterinarian or other qualified animal health professional and livestock production experts is recommended, not only when disease occurs but also to monitor bee health, biosecurity measures and management practices, so that shortcomings can be addressed before pathogens enter the apiary or cause evident (clinical) signs.

## 2.1 GOOD BEEKEEPING PRACTICES (GBPS)

GBPs should be considered as "a preventive tool able to properly control those factors that negatively affect honeybee health, with consequences on human health, environment and farm productivity." (Rivera-Gomis, Bubnic, Ribarits *et al.,* 2019). Despite the importance of GBPs, thus far, the scientific literature and relevant regulations covering the beekeeping sector have only contributed a few general references to their definition.

We have established a set of GBPs through a process of definition, validation, classification and evaluation so that a list of validated and effective practices can be shared with all stakeholders involved. The FAO–OIE *Guide to good farming practices for animal production food safety* (2009) and the collaboration of BPractices partners, a transnational project funded under the European Union's Horizon 2020 research and innovation programme, the European Research Area Network on Sustainable Animal Production (ERA-NET SusAn) (European Research Area on Sustainable Animal Production Systems, 2016) provided a starting point for this process.

GBPs are "integrative activities that beekeepers apply for on-apiary production to attain optimal health for honeybees, humans, and environment" (Rivera-Gomis, Bubnic, Ribarits *et al.,* 2019: 8). As such, their implementation has a positive effect on colony health, society and the environmental, in line with the One Health approach, thereby also favouring high production standards (Rivera-Gomis, Bubnic, Ribarits *et al.,* 2019) (see Figure 5).

GBPs have a very generic, universal approach. They have, indeed, a broadly common meaning and are not specific to any geographical area or bee disease. Nevertheless, they can properly prepare beekeepers to prevent and control the various honeybee diseases by taking the necessary measures.

### 2.1.1 Classification of GBPs

The GBPs were classified based on the OIE–FAO classification of good farming practices (GFPs), under the following headings: general apiary management, veterinary medicines, disease management (general), hygiene, animal feeding and watering, record-keeping, and training (Rivera-Gomis, Bubnic, Ribarits *et al.,* 2019) (see Table 2).

### 2.1.2 Identification of GBPs

An overall list of 251 GBPs was compiled from the average score provided by the different partners. This was then condensed into a smaller and more practical list of 140 GBPs

FIGURE 5
**GBPs within the One Health approach in beekeeping**

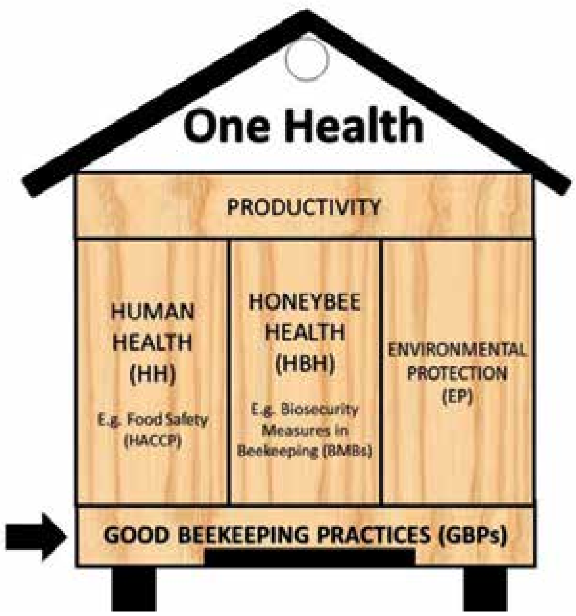


TABLE 2
**GBP headings and number of GBPs identified**

| Heading | Number of GBPs identified |
|---|---|
| General apiary management | 63 |
| Veterinary medicines | 8 |
| Disease management (general) | 23 |
| Hygiene | 7 |
| Animal feeding and watering | 7 |
| Record-keeping | 25 |
| Training | 7 |

TABLE 3
**GBP categories and number of practices identified**

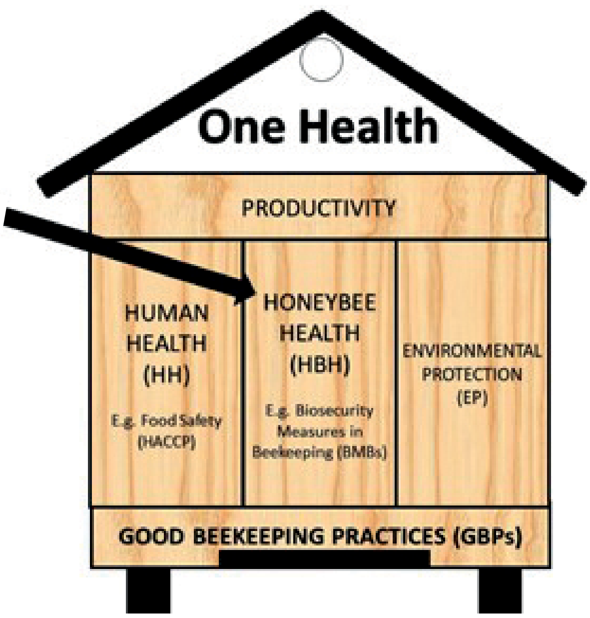
| GBP category | Number of GBPs identified |
|---|---|
| Honeybee health (HBH) | 109 |
| Product safety (PS) | 44 |
| Human health (HH) | 16 |
| Productivity (PR) | 45 |

for beekeepers, consisting of those with a mean score within the seventy-fifth percentile for each heading (see Annex 1) (Rivera-Gomis, Bubnic, Ribarits et al., 2019). Using the One Health approach, the following categories were identified: honeybee health (HBH), product safety (PS), human health (HH) and productivity (PR) (see Table 3). Some GBPs were included in more than one category (Rivera-Gomis, Bubnic, Ribarits et al., 2019).

GBPs also include monitoring of preclinical indicators. These are included in the honeybee health (HBH) category and are determined by in-field or laboratory diagnostic tests that detect the presence of honeybee diseases before they become clinically evident and reduce hive productions, cause honeybee health issues or, in the worst cases, lead to colony death. Examples of PCIs include the presence/quantity of honeybee pathogens like Varroa mites, *P. larvae* or *Nosema* spp. within the hive (this can be monitored with beekeeping, microscopical, cultural or biomolecular techniques).

Annex 1 contains a detailed and validated list of GBPs by importance and category.

FIGURE 6
**BMBs within the One Health approach in beekeeping**

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## 2.2 BIOSECURITY MEASURES IN BEEKEEPING (BMBS)

In addition to GBPs, there are Biosecurity Measures in Beekeeping (BMBs). GBPs are the foundation of sustainable and resilient beekeeping, and a prerequisite for the implementation of BMBs (Rivera-Gomis, Bubnic, Ribarits *et al.,* 2019). Together, GBPs and BMBs increase honeybee health and reduce the need for antimicrobials at the apiary level.

According to Dewulf and Van Immerseel (2018), "'biosecurity' refers to the combination of all the different measures implemented to reduce the risk of introduction and spread of disease agents." Biosecurity measures in Beekeeping (BMBs) are "all those operational activities implemented by the beekeeper to reduce the risk of introduction and spread of specific honeybee disease agents" (Pietropaoli, Ribarits, Moosbeckhofer *et al.,* 2021).

TABLE 4
**BMBs by category and disease**

| Disease | HBH (PCI) | PS | HH | PR |
|---|---|---|---|---|
| Varroosis | 21 (1 PCI) | 5 | 0 | 14 |
| American foulbrood | 19 (1 PCI) | 0 | 0 | 8 |
| European foulbrood | 18 (1PCI) | 0 | 0 | 6 |
| Nosemosis | 8 (1 PCI) | 1 | 0 | 5 |
| **Total** | **56 (4 PCI)** | **6** | **0** | **33** |

BMBs, unlike GBPs, vary according to geographical area, climate conditions, beekeeping technology, bee genetic (different races of breeds of bees) or due to the differing prevalence, virulence and economic impact of the pathogens. BMBs refer to each specific disease (e.g., BMs for varroa, BMs for AFB, etc.). BMBs are indeed related with local factors (e.g., climatic conditions, beekeeping technology, political decisions, bee breeds or races), stressors (e.g., nutritional, pesticides, predators, etc.) or different prevalence, virulence and/or economic impact of honeybee diseases. Recommendations and regulations of local authorities dictate the specific disease control strategies. In addition, BMBs are constantly evolving, depending on changes in the all mentioned factors listed above.

A list of 67 BMBs was drawn up by the BPractices Board of Experts for the four main honeybee diseases: varroosis, American foulbrood, European foulbrood and nosemosis (see Annex 2). These were then classified within the categories of honeybee health (HBH, which includes preclinical indicators – PCIs), product safety (PS), human health (HH) and productivity (PR) (see Table 4). Some BMBs were included in more than one category.

Most BMBs clearly have an impact on honeybee health (HBH) and hive productivity (PR). These two sectors are strongly linked given that keeping hives healthy increases productivity and profitability.

As in most livestock husbandry systems, there is a wide variety in beekeeping practices between and within areas. Moreover, regulatory provisions and compliance systems have a strong impact on disease management and implementation of control strategies. BMBs evolve and should be periodically reviewed depending on changes concerning new invaders, and more generally, changes in prevalence of honeybee pathogens and abiotic stressors (e.g. changes in climate that interfere with the biology of honeybees or pathogens).

External biosecurity refers to actions taken to prevent the introduction of infectious diseases into the apiary, while internal biosecurity refers to actions taken to prevent spread of infection within the apiary, between hives.

Both GBPs and BMBs are key to increasing the resilience and sustainability of beekeeping.

# Chapter 3
# How to use antimicrobials in beekeeping prudently and efficiently

In beekeeping, medicines are mainly used to control Varroa mites and small hive beetles. For Varroa mites, acaricides are frequently used in conjunction with several beekeeping techniques that can increase their efficacy. For small hive beetles, insecticides are frequently used in conjunction with mechanical methods, such as traps.

Antibiotics may be used for some honeybee infections caused by bacteria (European foulbrood or American foulbrood) or fungi (*Nosema* spp.).

This chapter discusses the use of antimicrobials in beekeeping, starting with pharmaceutical Varroa control methods.

In modern beekeeping, the course of action for *Varroa destructor* in *Apis mellifera* is management with acaricides, except in limited geographic areas like South Africa, where local honeybees (*Apis mellifera capensis* and *Apis mellifera scutellata*) are naturally resistant to the mite. In the rest of the world, this has proven very difficult to accomplish.

Nevertheless, it is strongly advisable to minimize the amount of acaricides applied at the apiary level, administering proper acaricide treatments at appropriate times during the year, or favouring active ingredients with a lower environmental impact.

Medical management of *Apis mellifera* without antibiotics is feasible and a significant milestone in sustainability. Beekeepers can instead reduce the presence of infectious diseases at the apiary level by adopting GBPs and effective BMBs, or selecting genetically resistant bees (which are not yet available).

Minimal or no use of medicines results in practically residue-free bee products. This increases market access and opens up the possibility of using quality marks for products (such as "organic"), which fetch higher prices on the market.

## 3.1 PROPER USE OF ANTIMICROBIALS: GENERAL CONCEPTS

Antimicrobials should not replace GBPs or BMBs.

It is important to follow the instructions on medicine packages on shelf life (for sealed as well as open vials) and storage temperature (e.g. placing it in a clean cupboard or refrigerator if cold storage is required).

Inappropriate or excessive use of antimicrobials is unlikely to improve animal health and can result in toxicity or antimicrobial resistance (AMR; see Box 1). It is therefore crucial to use antimicrobials in a medically responsible way.

## 3.2 ANTIMICROBIALS ACCESS AND HANDLING

Antimicrobials should only be used with a veterinary prescription or based on veterinary advice. All treated hives should receive the medicine at the correct dose and at the appropriate time. The instructions given by the veterinarian and printed on the label should be strictly followed.

BOX 1
**Antimicrobial resistance – what is it?**

Antimicrobial resistance (AMR) is a major global threat of increasing concern to human and animal health. It also has implications for food safety, food security and the economic well-being of millions of farming households.

AMR refers to when microorganisms – bacteria, fungi, viruses and protozoal parasites – develop resistance to antimicrobial substances, like antibiotics. This can occur naturally through adaptation to the environment. The pace of AMR's spread is now on the increase due to inappropriate and excessive use of antimicrobials.

Various factors are at play: lack of regulation and oversight of use; lack of awareness in best practices which leads to excessive or inappropriate use; the use of antibiotics not as medicines but as growth promoters in animals; over-the-counter or internet sales which make antimicrobial drugs readily available, and the common availability of falsified or poor-quality antimicrobials.

As a result of AMR, medicines that were once effective treatments for disease become less so or even useless, reducing their ability to successfully treat infections, mortality increases; there are more severe or prolonged illnesses; agriculture faces production losses; and livelihoods and food security are reduced.

The health consequences and economic costs of AMR are respectively estimated at 10 million human fatalities a year and a 2 to 3.5 percent decrease in global gross domestic product (GDP), amounting to USD 100 trillion by 2050. However, the full impact remains hard to estimate.

Source: FAO (2021)

Based on findings in human medicine, it is likely that in many countries, large volumes of antimicrobials sold are of substandard quality or falsified (Kelesidis & Falagas, 2015). This includes medicines with no or very low amounts of the active substance, expired medicines, or medicines with false labelling. Such medicines will not cure the diseased hives; rather, they may drive AMR and can even be dangerous for bees. As such, antimicrobials should only be purchased from licensed, credible dealers and/or established businesses, which stand behind the quality of the medicines they sell.

Outdated, leftover or expired medicines should be disposed of in environmentally friendly ways, such as returning them to the retailer or in appropriate disposal facilities. These antimicrobials may have lost much of their potency and might be harmful to diseased colonies. They may contribute to the development of resistant pathogens (bacteria, fungi or parasites) either in the hives (if used) or in the environment (if disposed of in an inappropriate way).

### 3.3 DISEASE DETECTION

Despite preventive measures and proper care, honeybees – just like humans – can still be affected by diseases.

A diseased hive may require treatment to guarantee its health and welfare and to ensure food production. Clinical examination of sick hives is crucial for determining a correct diagnosis and establishing a treatment plan or the biosecurity measures to apply. Sometimes, a laboratory diagnosis is needed to determine the exact disease agent and choose the most effective treatment. Unfortunately, laboratory capacity is highly variable between regions and cost and timing are also an issue, since it can take some days to diagnose disease. Thus, in regions with poor laboratory services and farmers, particularly smallholders with limited resources, the clinical skills of the veterinarian become even more important. In these cases especially, kits for on-field diagnosis (e.g. for American foulbrood or European foulbrood diagnostics) can be very useful, even if not cheap.

Frequent hive health checks (at least once a month, depending on the season) are important to detect suspected sick colonies as early as possible. Many diseases can spread very rapidly within apiaries or among close apiaries, especially through robbing behaviour,[2] so it is vital to act quickly and seek assistance from a competent veterinarian or bee health technician if necessary.

### 3.4 KEEPING RECORDS

Apiary record-keeping is essential, especially for professional beekeeping, and can save time and money. These records can be used to improve apiary productivity management, apiary health planning, and as medical history for future disease outbreaks. Having productivity and health data is essential to improve the profitability of the hives. Inclusion of data about type of medicine, dosage, indications for use, modality of administration and, if available, data from laboratory diagnostics and results of official controls are very helpful.

Moreover, it is very important to record dates of treatments and the type of treatment given (e.g. if associated or not with a specific beekeeping technique) to ensure that active ingredients are rotated (which is very important for Varroa control), and to evaluate final efficacy (e.g. by counting the amount of Varroa at the bottom of the hive or verifying the subsequent mortality of the hives).

### 3.5 ANTIBIOTICS CANNOT PROTECT AGAINST POOR BEEKEEPING PRACTICES

Antibiotic treatments are usually administered to hives via liquid sucrose syrup or medicated candy, but this also requires proper training of personnel/beekeepers to calculate correct dosage and avoid spillover treatment. A homogeneous distribution of the antibiotic within the syrup or the candy and sufficient uptake by all hives must be assured. After medication, containers/feeders should be carefully cleaned to avoid cross-contamination and residues.

In many countries, antibiotics are not registered for bees, so their use may be illegal (such as in the European Union, where they may only be administered under the "cascade prescription"[3]).

Antibiotics like tetracyclines, sulfonamides or tylosin may be effective, especially if associated with the beekeeping technique of the shook swarm, for some honeybee infections caused by bacteria, like European foulbrood (EFB) or American foulbrood (AFB) (in the latter case, it is important to note that they are not able to kill spores). Moreover, the antibiotic fumagillin may be effective for the treatment of the nosemosis caused by the microsporidium (fungus) *Nosema* spp..

Individual hive treatments should always be favoured, since "whole apiary" treatments promote the development and spread of AMR. The number of colonies treated and the spread of antibiotic residues via drifting should be minimized. Identification of sick hives (such as through hive labelling)

[2] Robbing behaviour is especially strong when there is little nectar in the field. Strong colonies with the largest stores are more likely to prey upon weaker colonies. Some robbing is carried out so secretly that it escapes notice. Most of the time, when robbing is taking place, bees from the opposing hives can be seen fighting. These fights can lead to significant loss of bees. Robbing may go on between hives in one apiary or hives of different apiaries.

[3] Where there is no suitable veterinary medicine authorized in a specific European Union member State for the specific condition being treated, to avoid unacceptable suffering, vets are permitted to use their clinical judgement to treat animals under their care in accordance with the cascade prescription (for more information, see glossary).

enables individual treatment and record-keeping. It may also be wise, where possible, to relocate the infected hive to an isolated "quarantine" apiary until it has recovered.

Antibiotics are sometimes given to healthy hives as a precaution to prevent, rather than treat, an infection (particularly AFB and EFB). Preventive use of antibiotics (also called "prophylactic use") is discouraged in livestock and should be discouraged in beekeeping too. In countries where the use of antibiotics in beekeeping is approved (such as the United States of America), they are intended for therapeutic purpose only. Antibiotics should only be used preventively in exceptional circumstances, such as when some hives in a group have been diagnosed with an infection that has most likely already infected, or will soon infect, the rest of the apiary and the consequences are likely to be severe. It may then be necessary to treat hives that are not yet infected/clinically ill but are at immediate and high risk of becoming infected and contributing to further disease spread.

Moreover, antibiotics are not effective for non-bacterial disease agents such as viruses, fungi (with the exception of *Nosema* spp.) and parasites. Therefore, it is essential to have a correct diagnosis before starting any antibiotic treatment. Not all antibiotics are effective against all bacteria, either. Antibiotic susceptibility, also called antibiotic sensitivity, refers to the likelihood that bacteria will be inhibited or killed by a certain antibiotic. This can vary even between different strains of the same bacterial species. Any superfluous use of antibiotics, such as for viral diseases, drives selection of resistant bacteria and threatens to make the next bacterial infection harder or even impossible to treat.

There are other reasons to discourage the use of antibiotics in beekeeping: the frequent relapses of these diseases; the contamination of the hive components and the likely release of antibiotics into hive products with possibility of generating residues in hive products; the risk, especially for AFB, to mask the disease, allowing a spread of subclinical infections within the whole apiary; the sustainability-oriented approach of modern beekeeping. Furthermore, antibiotics kill beneficial commensal (protective) bacteria which provide a natural barrier and defence system against pathogenic (disease-causing) bacteria, thereby removing the animal's natural defence and making it more vulnerable to opportunistic pathogens.

New tools to control bee pathogens that can even be used in organic beekeeping are under investigation, such as specific bacteriocins, probiotics, phytotherapeutic/essential oil products and bacteriophages.

## 3.6 CONCLUSION

The main advice for beekeepers on use of antimicrobials in beekeeping can be summarized as follows:

1. avoid/reduce use of antimicrobials and adopt GBPs and BMBs – medicines should never be considered a substitute for GBPs or BMBs;
2. only use antimicrobials according to a veterinarian's indication and the instruction label;
3. do not administer any antimicrobial during a honey flow or into honey supers;
4. do not misuse antimicrobials, including prophylactically, because it may lead to AMR;
5. spillover of antimicrobials may be toxic for honeybees and may lead to residues in hive products;
6. only use antibiotics for individual treatment on affected hives.

## Chapter 4
# Main honeybee diseases

Honeybees are susceptible to various diseases, some of which are highly contagious. It is very important for a beekeeper to be able to recognize the first signs of disease or infestation in hives and know how to proceed in its management. This knowledge may be acquired through specific training and on-field experience. This chapter briefly outlines important factors in the honeybee disease dynamic and classifies the main honeybee diseases, including the zoonosis, aspergillosis.

Honeybee diseases can be classified in two ways:

- the nature of the agent responsible for the disease: parasitic, fungal, bacterial or viral (this type of classification is more accurate);
- the function of the individuals affected in the hive: brood diseases or adult diseases (see Table 5).

In an increasingly globalized world, the international trade of bees and bee products is continuously growing. It has increased considerably over the past few decades in particular and is expected to continue to increase as technology makes transport easier and lowers national trade barriers.

All members of the World Trade Organization (WTO) have agreed to trading rules in the Agreement on the Application of Sanitary and Phytosanitary Measures, or SPS Agreement. Member States recognized OIE as the relevant international organization for developing standards, guidelines and recommendations on animal health.

The OIE *Terrestrial animal health code* is used as a basis for drafting veterinary regulations and guidelines governing the import and export of animals and animal products.

The honeybee diseases covered by the code are: acarapisosis (*Acarapis woodi*), varroosis (*Varroa* spp.), AFB, EFB, aethinosis (*Aethina tumida* or small hive beetle), and tropilaelapsosis (*Tropilaelaps* spp.).

Other bee diseases such as nosemosis, chalkbrood and all viral diseases are not currently covered by the OIE *Terrestrial animal health code* that provides standards for the improvement of animal health and welfare and veterinary public health worldwide, including through standards for safe international trade in terrestrial animals (mammals, reptiles, birds and bees) and their products. However, nosemosis is included in the OIE *Manual of diagnostic tests and vaccines for terrestrial animals.*

The OIE has also published measures for the safe trade and movement of bees for importing countries to prevent the introduction of bee diseases into their territory. There

TABLE 5
**Main honeybee diseases**

| Disease | Causative agent | Type | Individuals affected |
|---|---|---|---|
| Acarapisosis | *Acarapis woodi* | Parasitic | Adults |
| Varroosis | *Varroa destructor* | Parasitic | Adults and brood |
| Aethinosis | *Aethina tumida* (Small hive beetle) | Parasitic | Brood |
| Tropilaelapsosis | *Tropilaelaps* spp. | Parasitic | Adults and brood |
| American foulbrood (AFB) | *Paenibacillus larvae* | Bacterial | Brood |
| European foulbrood (EFB) | *Melissococcus plutonius* | Bacterial | Brood |
| Chalkbrood | *Ascosphaera apis* | Fungal | Brood |
| Stonebrood | *Aspergillus flavus* | Fungal | Brood |
| Nosemosis | *Nosema apis and Nosema ceranae* | Fungal | Adults |
| Amoebiasis | *Malpighamoeba mellificae* | Protozoal | Adults |
| Sacbrood virus (SBV) | Picornavirus | Viral | Brood |
| Chronic bee paralysis virus (CBPV) | *Cripaviridae* | Viral | Adults |
| Acute bee paralysis virus (ABPV) | *Dicistroviridae* | Viral | Adults |
| Deformed wing virus (DWV) | *Iflaviridae* | Viral | Adults |
| Black queen cell virus (BQCV) | *Dicistroviridae* | Viral | Brood |
| Israeli acute paralisysis virus (IAPV) | *Dicistroviridae* | Viral | Adults |
| Kashmir bee virus (KBV) | Dicistroviridae | Viral | Adults |

are currently no vaccines for bee diseases, so it is vital to control the spread of diseases by following the recommendations.

The prevalence of honeybee diseases should be periodically monitored to check whether they fulfil OIE's criteria for listed diseases (see chapter 1.2 of the *Terrestrial animal health code,* 2018).

## 4.1 VARROOSIS

*Varroa destructor* (*V. destructor*) is the mite responsible for varroosis, an external parasitic disease that attacks honeybee colonies (see Figure 7).

*V. destructor* is the biggest cause of economic losses in the beekeeping sector worldwide. It is present in almost all parts of the world – except for Australia – and has shown a strong ability to develop resistance to some of the available treatments. The mite affects both the brood and adult bees.

With the exception of a few subspecies of honeybee, if left untreated, an infested colony will become weaker over time and likely die. The mite weakens bees by feeding primarily on their fat body tissue. Weakened bees are more susceptible to many other diseases, especially viral pathogens (such as deformed wing virus or acute bee paralysis virus), which can wipe out entire bee colonies.

It is also important to verify visual signs of Varroa infestation during hive inspections, such as:

- the presence of mites on adult bees (these can easily be detected at the end of the productive season);
- scattered and discoloured brood pattern, with perforated cappings containing dead bees at the end of metamorphosis, unable to leave the cells;
- the presence of deformed bees: smaller, with stunted abdomens or deformed wings.

### 4.1.1 Control

Without a doubt, most *A. mellifera* colonies in temperate climates will be damaged or even collapse within a few years if no or inappropriate Varroa control methods are used (Boecking and Genersch, 2008; Rademacher and Harz, 2006; Rosenkranz, Aumeier and Ziegelmann, 2010). There are a wide range of different chemical substances, application techniques and methods to keep mite populations under control. Treatments include an array of different miticide options that are highly dependent on location, time of year, level of infestation and honey-flow period. All these factors should be considered to ensure treatment is effective in reducing the number of mites in the colony and preventing honey contamination (FAO, 2020).

Acaricide treatment strategies may include:

- **"Hard" acaricides:** these are used to control Varroa and include pyrethroids (e.g. fluvalinate, acrinathrin, flumethrin), organophosphates (e.g. coumaphos) and formamidine (e.g. amitraz). These are usually synthetic substances with a high environmental impact. They are not usually approved for organic beekeeping. Most do not require in-depth knowledge of the mite's biology and are easy to apply: they are mainly used as sustained-release formulations, most often in the form of chemical-impregnated strips. As lipophilic substances, they are mainly absorbed by the bees' wax, thus not directly jeopardizing the honey unless grossly misused. However, they are persistent and accumulate

FIGURE 7
**Left: Dorsal and ventral view of a *V. destructor* female -
Center: *V. destructor* female on a drone back - Right: *V. destructor* female on a pupa**

after repeated treatments. As a consequence, they may contaminate bee products in levels exceeding maximum residue limits. Other disadvantages of these miticides is that they may harm bees (Chauzat *et al.,* 2009) and create Varroa resistance, thus causing unrecognized failure of the control (Milani, 2001). Rotation of active ingredients is strongly advised to prevent AMR (FAO, 2020).

Unfortunately, the use of hard acaricides registered for plants containing pyretroids (e.g. fluvalinate, bifenthrin, ethofenprox) or organophosphates (e.g. clorphenvinphos, clorpyriphos, diazinon, pirimiphos-methyl) has been recorded in beekeeping (Spain, Ministry of Agriculture, Food and the Environment, 2016). Such use is illegal and can harm human health, bee health and the environment. It is critical to use products specifically registered for bees (FAO, 2020).

- **"Soft" acaricides:** these are acaricides with a low environmental impact and are usually approved for organic beekeeping. They include organic acids (e.g. formic acid, oxalic acid, lactic acid) and essential oils (e.g. thymol) (FAO, 2020).

  Apart from formic acid, they have only proven to be effective on phoretic Varroa. As such, their acaricide activity is higher when no capped brood is present in the hives. Formic acid has shown acaricide activity on not only phoretic Varroa, but also Varroa in the reproductive stage (i.e. within the sealed brood) (FAO, 2020).

  Organic compounds do not leave residual active ingredients that are dangerous for human health. Most of these substances are water-soluble and/or volatile and, furthermore, natural ingredients of honey. This makes contaminations that jeopardize the quality of honey or beeswax unlikely. So far, no issues of resistance have been reported with organic compound use (FAO, 2020).

  Their miticide effects and toxicity for honeybees depend on different climate and beekeeping conditions, such as active ingredient concentration, time and number of treatments, method of application (trickling, evaporating, spraying, sustained-release formulations, etc.), altitude and type of hive. For this reason, the climate and within-hive conditions and the mode of application should be carefully tuned for optimal effect. Compared with hard acaricides, the "therapeutic index" (the range between efficacy on Varroa and toxicity for the bee) of soft acacirides is lower and the final acaricide efficacy is often more variable. Beekeeper training is highly advisable (FAO, 2020).
- **Biotechnical methods:** Varroa infestation can be reduced by adopting biotechnical methods. These should be applied by experienced, trained beekeepers. They tend to be more time-consuming than the application of acacirides (FAO, 2020). The most commonly used biotechnical methods are:
  - **Drone brood removal:** this consists of reducing mite population growth by removing the drone brood. This technique is typical in spring, when bees increase drone brood. Elimination of drone brood does not seem to affect colony size or honey production (Calderone, 2005).
  - **Brood interruption:** this technique consists of a number of methods that interrupt the Varroa life cycle, stopping it from reproducing. It is achieved by caging the queen or confining her in a trapping comb or completely removing the brood (FAO, 2020).
- **Integrated control:** acaricide performance (hard or soft acaricides, organic or conventional) can be boosted by applying them in combination with biotechnical methods. For example, the hive can be treated more effectively by combining brood interruption with oxalic acid or amitraz treatments during its temporarily induced broodless stage (FAO, 2020).
- **Biological control:** this is another potential strategy against Varroa infestations but research is in its early stages and no biological commercial product for Varroa treatment is currently available. The most substantial efforts have been made with entomopathogenic fungi such as Metarhizium, Beauveria and Verticillium.
- **Selective breeding of Varroa-tolerant bees:** this is considered the best long-term solution. However, independent proof of "resistant lines" is lacking and it is often difficult to make recommendations concerning the use of commercially raised queens (Rosenkranz, Aumeier and Ziegelmann, 2010; FAO, 2020).

## 4.2 AMERICAN FOULBROOD

American foulbrood (AFB) is a bacterial disease that affects brood. "[It] is considered the most widespread and destructive infectious bee disease and it can cause serious economic losses to beekeeping. The term "American" does not refer to the disease originating from the United States of America, but rather to the fact that it was first identified and studied there" (FAO, 2020).

"AFB is caused by a spore-forming bacterium, *Paenibacillus larvae* (*P. larvae*). The spores can withstand a temperature of 100°C for several minutes in a suitable environment (e.g. in the intestine of the larvae) [and] a single spore can produce 250 million new bacilli after only 24 hours" (FAO, 2020). Spores can remain viable for more than 30 years in an infected hive, contaminating new colonies (FAO, 2020).

The affected brood is characterized by high mortality, and the broodcomb appears irregularly capped (see Figure 8).

FIGURE 8
**The "toothpick test" to diagnose AFB**

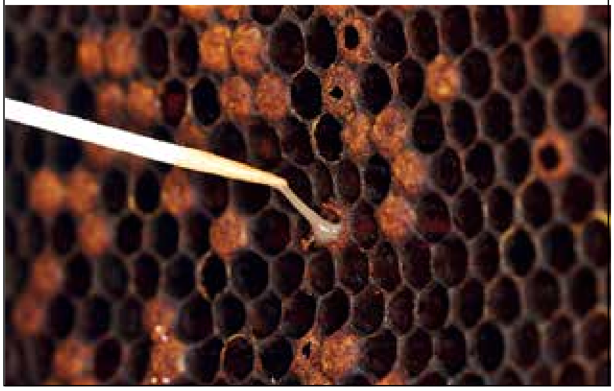

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FIGURE 9
**Incineration of infected combs**

©GIOVANNI FORMATO, IZSLT

FIGURE 10
**Dead larvae with EFB in open cells**

©PHOTO BY MASSIMO PALAZZETTI, ASL VT

### 4.2.1 Control

Appropriate action should be taken as soon as a case of AFB is detected to reduce the spread of the infection. AFB is mainly controlled through three different methods: antibiotic treatment, shook swarm or incineration (FAO, 2020): [4]

- **Antibiotic treatment:** in many countries, this is not allowed. Where it is allowed and there are antibiotics registered for use on honeybees against AFB, these do not guarantee total disinfection of the hive (they have a bacteriostatic rather than bactericidal effect) and are not effective against spores, increasing the risk of relapses and further spread of the infection. Furthermore, inappropriate use of antibiotics encourages AMR and risks the presence of medicinal residues in hive products. That said, antibiotic treatment can be effective, especially if combined with the "shook swarm" technique which may actually help reduce antibiotic contamination of hive products. The persistence of antibiotic residues may vary depending on the antibiotic selected: oxytetracycline decomposes fastest in honey, followed by streptomycin and sulphathiazole (Gačić *et al.,* 2015; FAO, 2020). Antibiotic treatment may be the treatment of choice (in countries where antibiotics are registered), in cases of early disease stage in strong colonies and in cases of high disease prevalence in the apiary (FAO, 2020). As stated in chapter 3, the golden rules for antibiotic use are as follows:
  - "be aware of and comply with regulations for the use of veterinary medicines in honeybees. Use antimicrobials only in accordance with regulatory requirements and other veterinary and public health guidance" (FAO, 2020: 41);
  - only use antimicrobials registered specifically for honeybees;
  - "keep detailed records of the origin and use of all medicines, including batch numbers, dates of administration, doses, treated hives and withdrawal times. Treated hives or apiaries should be clearly identified" (FAO, 2020: 41);
  - observe the required storage conditions for antimicrobials and feeds;
  - "ensure that all treatments or procedures are carried out properly, as described in the instructions (e.g. respecting the dose and method of application)" (FAO, 2020: 41);
  - "observe the withdrawal time of antimicrobials and ensure that products from treated hives are not used for human consumption until the withdrawal periods have elapsed" (FAO, 2020: 41).
- **The shook swarm method:** this "consists of shaking the bees from the infected combs (brood and store combs) into a clean hive with new frames and new

[4] If the colony is severely compromised, incineration is the best option.

TABLE 6
**Main differences between EFB and AFB**

| European foulbrood (EFB) | American foulbrood (AFB) |
|---|---|
| Dead larva in uncapped cell | Dead larva in capped cell |
| Sour smell | Smell of fish gelatin |
| Absence of blackening of honeycombs | Dark honeycombs, sunken and perforated cappings |
| Non-ropey dead larvae | Ropey dead larvae |
| Removable flake | Non-removable flake |

*Source:* FAO (2020)

foundations" (FAO, 2020: 41). This reduces the infection level, as the affected brood are the most contaminated. "Old, infected combs should be destroyed by incineration" (FAO, 2020: 41). This method "gives better results in the case of strong colonies and during the honey flow, as colonies will need to build new honeycombs starting from wax foundations" (FAO, 2020: 41).

- **Destruction of the hives by incineration** (see Figure 9): incineration of combs and honeybees after killing the bees (e.g. by asphyxia with sulphur dioxide, in the evening or at night) may be the best option in the case of "weak colonies; severe AFB clinical infection; when the disease appears outside of the honey flow (colony recovery is more difficult because it is impossible to build new honeycombs, and there high probability of relapse); and a very low prevalence of the disease in the apiary or in the geographical area" (FAO, 2020: 42) (when the goal is the eradication of AFB). "If the hive is in good condition, it may be disinfected using sodium hypochlorite and finally torching, after having first scraped off wax and propolis" (FAO, 2020: 42). Otherwise, it should be incinerated. "To destroy a hive by incineration and avoid further contamination, a hole at least 50 cm deep should be dug in the ground. Then the combs (and the hive, if needed) should be burned, and the hole should then be covered in soil" (FAO, 2020: 42).

### 4.2.2 Disinfection

All beekeeping equipment (boxes, boards, frames, queen excluders, etc.) and objects used for the manipulation of infected hives (e.g. hive tools, gloves, suit, etc.) should be properly disinfected. "Possible methods to use vary according to the substrate to disinfect. Wooden equipment can be scorched with fire and then sprayed with bleach or caustic soda. Objects can be dipped in hot paraffin or microcrystalline wax, or gamma-rayed" (FAO, 2020: 43). Clean the honey-house extraction tools/facilities (uncappers, centrifuge, sieves, pumps, spins, honey extractor etc.), the hive-product packaging materials (jars, tanks, barrels, etc.) thoroughly with detergent (FAO, 2020: 43). After applying detergent, be sure to rinse all items adequately.

## 4.3 EUROPEAN FOULBROOD

European foulbrood (EFB) is a bacterial disease that affects the honeybee brood. The genetic resistance of some species of bees to this disease may allow them to overcome infection without suffering serious damage, especially in favourable environmental conditions. However, it should be noted that even if prognosis is better than for AFB, in some areas, EFB has a more malignant manifestation, seriously damaging even strong bee colonies (FAO, 2020).

EFB is caused by the non-spore-forming bacterium *Melissococcus plutonius* (*M. plutonius*), often associated with other bacteria, including *Bacillus pumilis, Paenibacillus alvei, Paenibacillus dendritiformis, Enterococcus faecalis, Achromobacter eurydice* and *Brevibacillus laterosporus.* Depending on the species of bacteria associated with *M. plutonius,* EFB can present different clinical signs, such as the presence or absence of an unpleasant acidic smell.

*M. plutonius* is is quite resistant to adverse environmental conditions, remaining viable for several months in pollen.

The disease (Figure 9) can occur throughout the year, but it is more common in spring when there is more brood to feed due to an increase in the queen bee's egg deposition. This creates an imbalance between the increasing number of larvae and the few nurse bees that survive wintering, which may trigger EFB (FAO, 2020). In addition, the EFB would seem to be more common in cold and rainy spring, where there may be food shortages, particularly of protein for the brood due to lack of pollen (FAO, 2020).

"The health status of the colony plays an important role in the development of the disease. Weak colonies or colonies that are stressed for any reason (food shortage, migratory beekeeping, pesticides, etc.), as well as genetically more sensitive colonies, are especially prone to this disease. Healthy and strong colonies will be able to recover from the disease by themselves if the season guarantees adequate food sources (e.g. pollen and nectar)" (FAO, 2020: 46).

A typical sign of EFB is dead larvae in open cells, as they are killed before the cells are capped. "This is one of the features that differentiates EFB from AFB" (FAO, 2020: 46) (see Figure 10 and Table 6).

#### 4.3.1 Control

It is important to take appropriate actions as soon as possible when a case of EFB is detected, to reduce the spread of the infection. EFB is mainly controlled through the same three methods as for AFB: antibiotic treatment, shook swarm or incineration:[5]

- **Antibiotic treatment:** in many countries, this is not allowed. Where it is allowed and there are antibiotics registered for use on honeybees against AFB, these do not guarantee total disinfection of the hive (they have a bacteriostatic rather than bactericidal effect) and are not effective against spores, increasing the risk of relapses and further spread of the infection. Furthermore, inappropriate use of antibiotics encourages AMR and risks the presence of medicinal residues in hive products. That said, antibiotic treatment can be effective, especially if combined with the "shook swarm" technique which may actually help reduce antibiotic contamination of hive products. The persistence of antibiotic residues may vary depending on the antibiotic selected: oxytetracycline decomposes fastest in honey, followed by streptomycin and sulphathiazole (Gačić et al., 2015; FAO, 2020).

  Antibiotic treatment may be the treatment of choice (in countries where antibiotics are registered), in cases of early disease stage in strong colonies and in cases of high disease prevalence in the apiary (FAO, 2020). As stated in chapter 3, the golden rules for antibiotic use are as follows:
  - "Be aware of and comply with regulations for the use of veterinary medicines in honeybees. Use antimicrobials only in accordance with regulatory requirements and other veterinary and public health guidance" (FAO, 2020: 41).
  - Only use antimicrobials registered specifically for honeybees.
  - "Keep detailed records of the origin and use of all medicines, including batch numbers, dates of administration, doses, treated hives and withdrawal times. Treated hives or apiaries should be clearly identified" (FAO, 2020: 41).
  - Observe the required storage conditions for veterinary medicines and feeds.
  - "Ensure that all treatments or procedures are carried out properly, as described in the instructions (e.g. respecting the dose and method of application)" (FAO, 2020: 41).
  - "Observe the withdrawal time of veterinary products and ensure that products from treated hives are not used for human consumption until the withdrawal periods have elapsed" (FAO, 2020: 41).
- The shook swarm method: this "consists of shaking the bees from the infected combs (brood and store combs) into a clean hive with new frames and new foundations" (FAO, 2020: 41). This reduces the infection level, as the affected brood are the most contaminated. "Old, infected combs should be destroyed by incineration" (FAO, 2020: 41). This method "gives better results in the case of strong colonies and during the honey flow, as colonies will need to build new honeycombs starting from wax foundations" (FAO, 2020: 41).

  In the case of EFB, which is usually less severe than AFB, a "partial shook swarm" may be performed, taking out only brood combs (which are the most infected material) and leaving the store combs (FAO, 2020). "This will allow the colony to recover more quickly and produce honey for human consumption within a few months" (FAO, 2020: 47).
- Destruction of the hives by incineration: incineration of combs and honeybees after killing the bees (e.g. by asphyxia with sulphur dioxide, in the evening or at night) may be the best option in the case of "weak colonies; severe EFB clinical infection; when the disease appears outside of the honey flow (colony recovery is more difficult because it is impossible to build new honeycombs, and there high probability of relapse); and a very low prevalence of the disease in the apiary or in the geographical area" (FAO, 2020: 42) (when the goal is the eradication of AFB). "If the hive is in good condition, it may be disinfected using sodium hypochlorite and finally torching, after having first scraped off wax and propolis" (FAO, 2020: 42). Otherwise, it should be incinerated. "To destroy a hive by incineration and avoid further contamination, a hole at least 50 cm deep should be dug in the ground. Then the combs (and the hive, if needed) should be burned, and the hole should then be covered in soil" (FAO, 2020: 42).

#### 4.3.2 Disinfection

All beekeeping equipment (boxes, boards, frames, queen excluders, etc.) and objects used for the manipulation of infected hives (e.g. hive tools, gloves, suit, etc.) should be properly disinfected. "Possible methods to use vary according to the substrate to disinfect. Wooden equipment can be scorched with fire and then sprayed with bleach or caustic soda. Objects can be dipped in hot paraffin or microcrystalline wax, or gamma-rayed" (FAO, 2020: 43). Clean the honey-house extraction tools/facilities (uncappers, centrifuge, sieves, pumps, spins, honey extractor etc.), the hive-product packaging materials (jars, tanks, barrels, etc.) thoroughly with detergent (FAO, 2020: 43).

[5] If the colony is severely compromised, bee killing and incineration is the best option.

## 4.4 NOSEMOSIS

Nosemosis is a disease of adult bees caused by unicellular fungi belonging to the Nosema genus of the *Nosematidae* family.

There are two different species of *Nosema* that affect *Apis mellifera,* with different prevalence depending on the area: *Nosema apis* (*N. apis*) and *Nosema ceranae* (*N. ceranae*). Both have a dormant stage as spores.

The spores are hard to distinguish morphologically and represent the resistant and propagation form of the disease (FAO, 2020) (see Figure 11). Spores can remain infectious from a few days up to five years at low temperatures (FAO, 2020). "Heat, as well as solar ultraviolet radiation, can kill them in a few hours" (FAO, 2020: 29). *N. apis* spores survive well in cold and freezing conditions, while *N. ceranae* spores are killed at low temperatures, preferring higher temperatures (up to 60°C), and can survive desiccation.

Nosemosis is influenced by many factors:

- "wet and cold spells increase the chances of infection among bees of the same hive because they force the bees indoors;
- scarcity of honey and pollen flows;
- seasonal patterns can also affect the spread of infection. During long, cold winters and cold, rainy springs, the bees may not find nectar and pollen;
- frequent hive inspections during adverse weather conditions (e.g. winter season, windy or rainy weather) can trigger the onset of the disease as well as its propagation due to the induced stress;
- the presence of other diseases (such as amoebiasis, varroosis or viruses) exacerbates the symptoms of nosemosis" (FAO, 2020: 29);

"*Nosema apis* is responsible for the "classic" known form of the disease, which is widespread especially in cold and wet areas. It appears more easily during spring and in mismanaged hives during winter. It occurs mainly with a decrease in the colony population. The disease never affects the larval stages and seldom the queen. *Nosema apis* spores, found in the faeces of the bees, are directly or indirectly ingested by adult honeybees and develop in the intestines of the bees, affecting their digestive functions… Spores are expelled with faeces and can be swallowed by other bees, which become infected" (FAO, 2020: 30). The fungus also affects the nutrition glands, abruptly interrupting their secretion. The bees can no longer feed the brood and consequently, colony renewal comes to a halt.

*N. ceranae* is a recently identified species of fungus, first isolated in 1996 by Fries on *A. cerana*, a bee species widespread in Southeast Asia (FAO, 2020). It was first isolated in *A. mellifera* by Higes in 2006 (FAO, 2020). *N. ceranae* has spread across Europe, replacing the indigenous *Nosema* species on *A. mellifera*, *N. apis*.

Concerning nosemosis from *N. apis,* the following clinical signs will appear:

- intestinal disorders, such as diarrhoea (see Figure 12);
- inability to secrete royal jelly;
- reduction in the activity of foraging bees until it stops completely;
- in the rare cases in which the queen is sick, a marked decrease in egg-laying (FAO, 2020).

First, there is a slow depopulation, work decreases and the colony becomes restless (FAO, 2020). Some bees stop being able to fly and walk with their wings paralysed, spread out in "K" form, while other bees gather in small groups (FAO, 2020).

Eventually, dead bees with swollen abdomens and legs retracted below the chest can be observed on the bottom of the hive. The running board of the hive entrance and the honeycombs become smeared with diarrhoea (FAO, 2020).

Unlike *N. apis, N. ceranae* occurs throughout the year. It attacks the intestine (midgut) of the bees, causing malabsorption. Diarrhoea is typically absent. "It seems that foraging bees die away from the hive, causing a progressive depopulation of the colonies" (FAO, 2020: 30) until there is total loss.

FIGURE 11
**Microscopic *Nosema* spp. spores**

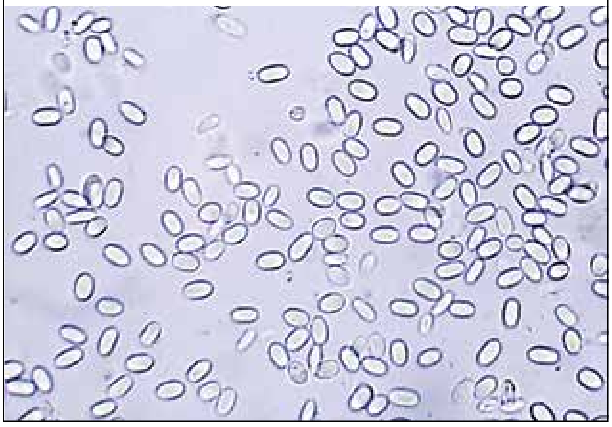

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FIGURE 12
**Honeycomb smeared with *Nosema*-infected diarrhoea**

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### 4.4.1 Control

Unfortunately, prognosis is frequently poor because its onset usually goes unnoticed, and clinical signs are only seen at an advanced stage of disease. Generally, affected colonies do not recover spontaneously, and require the beekeeper's intervention.

Antibiotic treatment for bees is registered in some countries. Fumagillin is one such antibiotic, obtained from *Aspergillus fumigatus* and discovered in 1951. It is administered by feeding the infected bees with medicated sucrose syrup. Nevertheless, the use of fumagilin in colonies heavily infected with *N. ceranae* has not been found to improve size or survival of colonies during the inactive season, independently of dose or administration strategy (Williams, Shutler and Rogers, 2010; Mendoza *et al.*, 2017). Moreover, a recent re-evaluation of commercial hive products indicates the possible presence of fumagillin as a salt, dicyclohexylamine (DCH). This chemical is a potential human health and food safety hazard since it is five times more toxic than fumagillin, based on studies conducted on rats (van den Heever *et al.,* 2014). As such, caution and control should be exercised in honey production when using these substances (Martel *et al.,* 2006).

If disease is advanced, colony destruction is advised, particularly in weak colonies.

Hive materials can be retrieved after killing the bees, sterilizing the hives (with boiling water, 6 percent soda and a blue flame) and destroying the combs. Infected honey and pollen should not be used to feed other bees to prevent transmission. If the affected colony is very strong, move it to a sun-exposed area (not windy and cold) with a clean hive and combs to reduce chances of reinfection from diarrhoea, provide proper feeding (e.g. molasses, herbs or medicated feed) and replace the queen. Infected combs should be destroyed, and the hive should be sterilized or destroyed. The honey can be used for human consumption.

## 4.5 STONEBROOD (ASPERGILLOSIS)

Fungi belonging to the *Aspergillus* genus are ubiquitous in the soil and can cause disease in insects, birds and mammals, including humans (especially those who are immunocompromised), making aspergillosis a zoonotic disease (FAO, 2020). In humans, *Aspergillus* fungi may cause:

- respiratory diseases like pulmonary infections (broncopulmonary aspergillosis, pulmonary aspergillomas) or allergic bronchitis, if inhaled;
- infections of the eye, pharynx, skin and open wounds in case of direct contact (FAO, 2020; Mousavi *et al.,* 2016).

Moreover, as fungi belonging to the *Aspergillus* genus multiply, they produce specific mycotoxins that may be dangerous when transmitted to animals and humans ingesting contaminated food. Regarding bee products, mycotoxins may be transmitted to humans through the consumption of pollen.

Stonebrood, or aspergillosis, is a honeybee disease caused by different species of fungi belonging to the *Aspergillus* genus. "The main species of fungi responsible for the disease in honeybees are *Aspergillus flavus* and less frequently, *Aspergillus fumigatus* and *Aspergillus niger*" (FAO, 2020: 55) (and occasionally other species, according to Nardoni *et al.,* 2017). Symptomatic disease is quite rare, but nonetheless widespread throughout the world, affecting brood (larvae and pupae) and, rarely, adult bees (Batra, 1973). Many species of *Aspergillus* produce aflatoxins, which may contribute to the death of the brood (Burnside, 1930).

"The ideal temperatures for the development of the fungi is between 33°C and 37°C, but they can also multiply at temperatures between 7°C and 40°C. Exposure to temperatures above 60°C for a minimum of 30 minutes can devitalize both spores and hyphae" (FAO, 2020: 55).

The infection is spread through ingestion of contaminated food – primarily pollen (Foley *et al.,* 2012) – containing *Aspergillus* fungal spores, or by direct contact between bees. Adult bees only become infected via ingestion, whereby the mycelium penetrates through the walls of the bee's intestine and spreads to the rest of the body.

The disease can spread from sick hives to healthy ones through drifting, robbing or swarming (FAO, 2020). "The beekeeper can also transmit the disease by using contaminated bee tools or by moving the combs from sick colonies to healthy ones" (FAO, 2020: 56).

"One of the first signs of the disease is a spotted and irregular brood pattern (high quantity of empty cells, mixed with other cells containing eggs, larvae and nymphs of all ages)" (FAO, 2020: 56). "In honeybee larvae, the infection gives rise to a characteristic ring near the head of the infected larvae…Once the larvae die, which occurs in the capped cells, their bodies harden, appearing as small stones (Figure 13) that are difficult to crush; hence the name, 'stonebrood'" (FAO, 2020: 55). Eventually, the fungus produces enough spores to completely fill the cell containing the infected larvae.

The dead larvae initially appear wrinkled and cream-coloured before going mouldy and mummifying. They often become covered with a sort of felt made up of the fungal spores, starting from the head. The colour of this felt differs depending on the species of *Aspergillus* involved: yellowish-green for *A. flavus,* grey-green for *A. fumigatus* or black for *A. niger* (FAO, 2020). If no spores develop, the felt remains greyish-white. The larvae mummify and become difficult to extract from the brood cells, even with tweezers (FAO, 2020; Seyedmousavi *et al.,* 2015). In cases of strong fungus growth, the fungus can fill the cells before they are capped.

The disease kills adult bees because of the mycotoxins produced rather than fungemia. "Infected bees will initially appear excited and restless, this state giving way to paralysis, inability to fly and death, usually occurring far away from the hive" (FAO, 2020: 56). After death, the body becomes hard, and in humid conditions, it can be covered with the typical grey-white fungal felt (FAO, 2020).

"Although the death of entire colonies of bees affected by the fungus has been observed, the disease usually has a transitory character" (FAO, 2020: 56) and tends to resolve spontaneously. Little is known about the sensitivity of bees to this disease.

### 4.5.1 Control

"More research is needed to determine the proper control measures to adopt. The replacement of the queen can be very useful. To date, there are no registered treatments to control this infection in bees, although experimentally it has been observed that the essential oils of cinnamon (*Cinnamomum zeylanicum*), *Litsea cubeba* and geranium (*Pelargonium graveolens*), as well as their mixtures, are able to contain the growth of this fungus. Genetic selection for bee resistance to stonebrood could be an interesting sector to invest effort in, as it has been observed that a genetic predisposition may differ from colony to colony" (FAO, 2020: 56).

## 4.6 AETHINOSIS

*Aethina tumida* (Murray, 1867) (order Coleoptera, family Nitidulidae – Small Hive Beetle - SHB), is native to sub-Saharan Africa but over the past few decades it spread in various regions of the world (United States of America, Canada, South and Central America, Australia, Egypt, Italy, Korea and the Philippines).

Adult SHBs (Figure 14) are excellent fliers (capable of flying >10 km) and can survive up to 12 months. More than 1000 adult beetles may occur within a colony and can be fed by worker bees via trophallaxis. Females oviposit several eggs (about 1000 eggs in their lifetime) in typical clutches in small cracks or within capped brood cells. The larvae emerge from the eggs after 1–6 days (most within 3 days) and feed on pollen, honey and bee brood until their development that takes about 2 weeks. Following this, the larvae reach the wandering phase and leave the colony to pupate in the soil surrounding the colony. Pupation takes about 2–12 weeks after which adults leave the soil and fly to search for new host colonies.

Bee colony damage is due to adult beetles, that can cause colonies to abscond, but mainly due to larval feeding behaviour that causes severe damage to combs, honey fermentation and full structural collapse of the nest.

### 4.6.1 Control

At the apiary level, good beekeeping practices related to *Aethina tumida* are usually the best way to avoid the related-damage and to reduce the use of chemicals to control the pest.

If necessary, different control methods can be adopted, both at the apiary level and inside the honey house. The combination of different control strategies is the best solution to apply. The first strategy should be to install mechanical traps or biological control methods and only subsequently chemical control methods (i.e. when the population of beetles threats the survival of the colony).

Mechanical traps (e.g. provided with glue or baits) are able to support the monitoring and controlling activities of the parasite inside the hives.

Successful egg emergence is correlated with relative humidity, with fewer eggs hatching at a relative humidity of <50%. For this reason, in the honey house a controlled

FIGURE 13
***Stonebrood***

©CARLO FERRARI (ASL ROMA 5)

FIGURE 14
***Aethina tumida* adult**

©GIOVANNI FEDERICO (IZSME)

humidity and temperature can avoid SHB multiplication. Moreover, a fluorescent light source positioned on the floor of the extraction room overnight attracts the SHB larvae. In this way they may be collected and destroyed by putting them in alcohol or detergent solution.

## 4.7 TROPILAELAPSOSIS

*Tropilaelaps* spp. (Anderson & Roberts, 2013) (order Mesostigmata, family Laelapidae) are mites that occur in: Indonesia (Sulawesi Island) and Philippines - *Tropilaelaps clareae;* mainland Asia and Indonesia (except Sulawesi Island) - *Tropilaelaps mercedesae.*

*Tropilaelaps mercedesae* and *Tropilaelaps clareae* are also parasites of the introduced *A. mellifera* in these regions.

Similarly to *Varroa destructor,* the colonising *Tropilaelaps* female lays from one to four eggs on a mature bee larva shortly before the brood cell is capped. The drone brood is preferred and the mite progeny, usually one male and several females feed on and seriously damage the bee larva (Figure 15). Development of the mite requires about 1 week. Adults, including the foundress female, emerge with the adult bee and search for new hosts. Reproductive-cycle inside brood cells is very short and permit a faster population increase than Varroa mites. Phoretic survival of *Tropilaelaps* mites on bees is quite short (only 1–2 days).

*Tropilaelaps* can act as a potential vector for honeybee viruses, such as deformed wing virus (DWV), resulting in death of bee larvae (up to 50%), irregular brood patterns and malformations of bee adults.

### 4.7.1 Control

Even if the use of "hard" acaricides, organic acids and essential oils is common in the beekeeping sector, a variety of beekeeping practices, like brood interruption, can be used as an Integrated Pest Management strategy to reduce the infestation and the use of chemicals into the colonies.

## 4.8 WAX MOTH

The term wax moth is a common name which refers to different species of moths that invade, attack, and damage honeybee colonies and hive products. The most common ones are the greater wax moth *G. Mellonella* (Figure 16) and the lesser wax moth *Achroia grisella.* The last one is less destructive and less common.

The greater wax moth is ubiquitously distributed everywhere beekeeping is practiced.

The duration taken by the moth to complete its life cycle varies from weeks to months and is affected by both biotic (intra-and interspecific) and abiotic factors. Temperature averages of 29–33°C is optimum for development. Oviposition begins a fairly short time after emergence and mating of females. Eggs are deposited in clusters of 50–150 in cracks or crevices inside the hive. Upon hatching, the wax moth larvae move from the cracks and crevices onto honeybee comb where they begin to feed on honey, pollen, and brood, destroying the comb structure. Larvae take between 28 days and 6 months before pupation. The greater wax moth pupa is immobile, does not feed, and is housed in cocoon.

### 4.8.1 Control

Good beekeeping practices are fundamental to reduce reproduction and consequently damage due to the wax moth. Keeping strong colonies, with adequate food sources, and sealing cracks and crevices of hives, are two common practices. Not-used equipment (e.g. combs) can be exposed to temperatures above (heating technique) or below (freezing technique) the tolerance range of the wax moth eggs and larvae. Moreover, fumigants are used at large scale against wax moth like acetic acid, formic acid and carbon dioxide.

Biological control of the wax moth is also common with the use of spores of *Bacillus thuringiensis.*

FIGURE 15
***Tropilaelaps* mites on bee pupae**

©DENIS ANDERSON (CSIRO)

FIGURE 16
**Wax moth larva**

©MASSIMO PALAZZETTI

Chapter 5

# The Progressive Management Pathway (PMP) in the beekeeping sector

## 5.1 INTRODUCTION

The Progressive Management Pathway (PMP) is a tool developed to assist countries, industries and producers to implement appropriate and sustainable levels of risk management in livestock or aquaculture production systems, including those for beekeeping. The Progressive Management Pathway for Biosecurity Measures in Beekeeping (PMP-BMB) is an extension of the Progressive Control Pathway (PCP), which has been internationally adopted as a systematic framework for planning and monitoring risk reduction strategies for control of major livestock and zoonotic diseases.

Most PCPs relate to control of single diseases or disease complexes. In contrast, the PMP focuses on building management capacity through a bottom-up approach with strong stakeholder involvement to promote application of risk management at the producer level, as part of the national approach.

In these guidelines, two different applications of PMP are described: one for biosecurity management, and the other for AMR management.

## 5.2 THE PROGRESSIVE MANAGEMENT PATHWAY FOR BIOSECURITY MEASURES IN BEEKEEPING

The Progressive Management Pathway for Biosecurity Measures in Beekeeping (PMP-BMB) (see Figure 16) is a process devised for modern beekeepers. It sets out the steps required for sustainable, healthy and resilient beekeeping. The pathway is split into four stages applicable on a global scale to help beekeepers achieve sustainability and colony health. It is based on the idea that GBPs, in conjunction with the correct BMBs, will manage risks and lead to optimal colony health, thereby reducing the need for pharmaceutical interventions and improving overall product quality, consumer confidence and environmental outcomes.

Before beginning the pathway, the intention to keep bees should be made clear and the collaboration of local authorities, local beekeepers and experts, as well as government support, should be sought. This is necessary to obtain all the information needed and formulate a Biosecurity Management Plan (BMP).

The four stages are as follows:

### Stage 1 – Risk Assessment (surveys)

In the first stage, collaboration between different stakeholders focuses on assessing the current status of beekeeping practices, the associated risks and the extent to which biosecurity measures may already be applied in beekeeping. The risk assessment will likely be carried out through specific field surveys that will help the expert group to establish the general level of beekeeping knowledge and understanding (see Annex 3 for an example). The results of these surveys will serve as a basis for determining the BMP.

### Stage 2 – Local/Provincial Biosecurity (Biosecurity Management Plan)

This step involves the implementation of a BMP at the local or provincial level.[6] The BMP includes GBPs and BMBs validated and approved by local beekeepers to be applied as part of daily apiary management.

### Stage 3 – National Biosecurity (National Biosecurity Management Plan)

This step revolves around expanding these efforts to the national level by developing a National Biosecurity Management Plan (NBMP). This plan must be made accessible to all beekeepers.

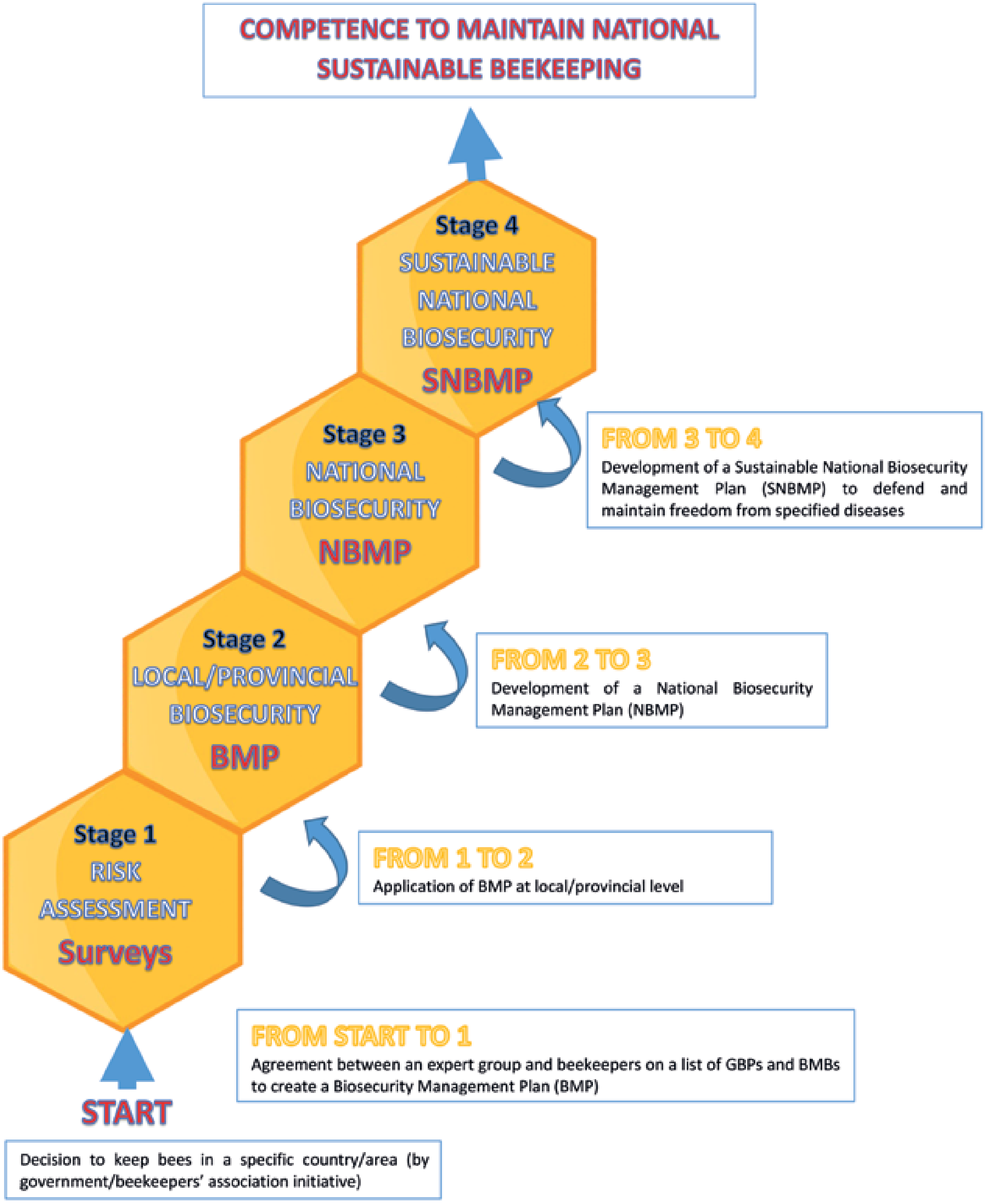
### Stage 4 – Sustainable National Biosecurity (Sustainable National Biosecurity Management Plan)

This step focuses on the development of a Sustainable National Biosecurity Management Plan (SNBMP), employing the indications laid out in the plan to reduce the use of antimicrobials and instead focus on the prevention and control of diseases through correct management, beekeeping techniques, integrated pest management, biosecurity measures and organic medicinal treatments.

This follows the One Health approach, protecting the health of the environment, animals and humans, increases food security and creates sustainable, resilient livelihoods in apiculture.

[6] This stage should also be incorporated into a beekeeping industry that wishes to compartmentalize.

FIGURE 17
**The Progressive Management Pathway for Biosecurity Measures in Beekeeping (PMP-BMB)**



"Competence to maintain national sustainable beekeeping" is defined as reduction in the emergence of new honeybee diseases, elimination of circulating diseases, and a platform for the prevention, early detection of and sustainable response to threats. This can then provide and maintain international confidence in management (ICM) and ease international trade.

## 5.3 THE PROGRESSIVE MANAGEMENT PATHWAY FOR ANTIMICROBIAL RESISTANCE IN BEEKEEPING

As explained, the PMP is a tool to assist countries to implement sustainable measures to manage risk in livestock production systems. The aim of the PMP-AMR in beekeeping is to assist countries in developing and implementing a multisectoral One Health National Action Plan (NAP) to combat AMR, with a focus on the beekeeping sector.

The availability and use of antimicrobials, not just in bees, but in all terrestrial and aquatic animals and crops, are essential to health and sustainable agriculture production. They contribute to food security, food safety and animal welfare, and in turn, to the protection of livelihoods and the sustainability of animal crop production.

AMR can occur naturally through adaptation to the environment, but misuse and overuse of antimicrobials speeds up the process. AMR is a global, multisectoral problem encompassing humans, animals, plants and the environment. It requires a similarly multisectoral approach at the national level with actions spanning the policy and regulatory spheres, preventive actions, and engagement with producers and other stakeholders.

The World Health Organization (WHO), in collaboration with FAO and OIE, developed a global action plan on AMR to ensure availability of treatment with effective and safe medicines. The member States of each of the three organizations agreed to implement the global action plan using the One Health approach to address AMR in human, animal and plant health, as well as in food and the environment. An effective approach should involve all sectors of government and society.

In addition to this, in 2015, FAO developed and adopted an Action Plan on AMR (2016–2020) within its Strategic Programme. It addressed four major "Focus Areas" that have been here applied to the beekeeping sector:

- to improve awareness on AMR and related threats (Figure 18);
- to develop capacity for surveillance and monitoring of AMR and antimicrobial use (AMU) in food and agriculture (Figure 19);
- to strengthen governance related to AMU and AMR in food and agriculture (Figure 20);
- to promote good practices in food and agriculture and the prudent use of antimicrobials (Figure 21).

The PMP helps countries and individual sectors (key sectors identified by countries) measure their progress on optimal and sustainable use of antimicrobials. It sets out specific activities to implement, achievements and key performance indicators for each Focus Area, in stages. Furthermore, the Excel-based PMP guides the user through the list of activities and targets that should be implemented or met, with a dashboard showing progress made over time for each of the four Focus Areas.

In this way, the PMP-AMR in beekeeping is an important new tool facilitating responsible use of antimicrobials in this sector, in line with the One Health approach.

FIGURE 18

**Action Plan on AMR for the "Awareness" Focus Area**

## AWARENESS

Goal: Improve awareness and understanding of GBPs, BMBs, AMU and AMR

### STAGE 1 (assess awareness)

- Gather data (e.g. literature, scientific data, inventory, existing training on AMU and AMR)
- Carry out surveys on awareness of AMU, AMR, GBPs and BMBs
- Engage with and assess education and training programmes
- Develop educational and training materials for key stakeholders (beekeepers, vets, veterinary paraprofessionals) on AMU, GBPs and BMBs

### STAGE 2 (local/provincial awareness)

- small-scale
- Implement educational and training materials for key stakeholders (beekeepers, vets, veterinary paraprofessionals) on GBPs, BMBs AMU and AMR
- Review core curricula of vets and veterinary professionals and develop a plan to ensure coverage of GBPs, BMBs, AMU and AMR

### STAGE 3 (nationwide awareness in beekeeping)

- Launch an awareness campaign targeting key stakeholders at the national level with effective communication methods
- Revise core curricula of vets and veterinary paraprofessionals to ensure coverage of GBPs, BMBs, AMU and AMR

### STAGE 4 (Sustainable management of AMU)

- Organize training courses to promote alternatives to antimicrobials with high environmental impact
- Promote integrated control through adoption of proper beekeeping techniques
- Repeat survey from Stage 1 to assess progress made on awareness
- Revise and re-launch awareness campaigns

FIGURE 19
**Action Plan on AMR for the "Evidence" Focus Area**

**EVIDENCE**
Goal: Develop capacity for monitoring and surveillance of GBPs, BMBs, AMU and AMR

**STAGE 1**
**(AMU assessment and development of AMU and AMR surveillance)**

- Verify antimicrobials in use in beekeeping
- Determine routes and flows of antimicrobials
- Assess laboratory capacity concerning diagnosis of honeybee diseases and detection of antimicrobial residues in hive products
- Develop operational plans for monitoring antimicrobials sold/used in bees
- Develop operational plans for monitoring antimicrobial residues in hive products
- Develop operational plans for monitoring honeybee diseases
- Develop operational plans for monitoring GBPs/BMBs

**STAGE 2**
**(AMU/AMR surveillance at local level)**

- Implement operational plans to improve traceability of antimicrobials used on bees at local/provincial level
- Develop laboratory capacity for honeybee diseases diagnosis and residue quantification in hive products at local/provincial level
- Implement operational plans for surveillance of antimicrobial residues in hive products and AMR at key production sites (apiaries and honey houses of professional beekeepers) at local/provincial level
- Implement operational plans to monitor application of GBP/BMBs
- Develop a national plan for surveillance (active/passive) of antimicrobial residues in honey products and AMR

**STAGE 3**
**(nationwide AMU and AMR surveillance in beekeeping)**

- Implement national surveillance for antimicrobials sold to end used according to animal species
- Report data on total quantity of antimicrobials sold to end users according to animal species and type of use (therapeutic, medicated feed, growth promotion)
- Implement national surveillance of pathogens in hive products for for human consumption (honey houses and shops)
- Implement passive and active surveillance on hives (infected and healthy)
- Systematically collected, analyze and report data

**STAGE 4**
**(nationwide AMU and AMR surveillance in all sectors)**

- Implement a national monitoring/surveillance system for priority pathogens and AMU in humans, animal and plants
- Ensure that laboratory capacity concerning AMR generates reliable data
- Collect and report data on antimicrobials sold/used in animals and plants

FIGURE 20

**Action Plan on AMR for the "Governance" Focus Area**

## GOVERNANCE

Goal: strengthen governance (political commitment, policy, regulatory framework) related to GBPs, BMBs, AMU and AMRR

### STAGE 1
### (situational analysis and assessment)

- Establish a multisectoral coordination group (MCG): ministries, stakeholders (eg. key One Health partners/industries, funding organizations) and a Technical Working Group to perform situational analysis
- Collection information on AMR burden in humans, animals and plants
- Identify gaps and measures for improvement
- Identify and validate GBPs/BMBs, in collaboration with beekeepers
- Evaluate behaviour of vets and beekeepers towards known drivers of AMR, their knowledge of GBPs/BMBs/AMU/AMR)
- Analyse potential national/international obligations (OIE/Codex standards)
- Review existing National Action Plan (NAP)
- Assess veterinary services
- Draft a regulatory framework to develop monitoring/surveillance systems on GBPs/BMBs/AMU/AMR
- Set a time frame to develop a NAP

### STAGE 2
### (estabilish a governance mechanism at local/provincial level)

- Ensure legislation/policy in place supporting adoption of harmonized and validated GBPs/BMBs and/or integrated strategies (chemicals and beekeeping techniques) to prevent and control honeybee diseases at local/provincial level
- Set up a rewards system (eg. Reduction of controls, simplication of beehive movement in migratory beekeeping, refunds of hives destroyed due to notifiable diseases) for beekeepers who respect AMU and observ validated GBPs/BMBs at local/provincial level
- Identify funding sources to implement at least year 1 of the plan at local/provincial level
- Develop a National Biosecurity Management Plan (NBMP), including a NAP and operational plan on AMR in beekeeping

### STAGE 3
### (National Biosecurity Management Plan)

- Obtain government approval for NBMP, including NAP and operational plan on AMR in beekeeping
- Implement the NBMP
- Develop a Sustainable National Biosecurity Management Plan (SNBMP)

### STAGE 4
### (SNBMP implementation and review)

- Implement the SNBMP in beekeeping
- Ensure legislation/policy in place discouraging AMU and supporting adoption of strategies with low environmental impact to control honeybee diseases
- Monitor progress on application regularly

FIGURE 21
**Action Plan on AMR for the "Practices" Focus Area**

**PRACTICES**
Goal: promote GBPs, BMBs, and responsible AMU

**STAGE 1**
**(risk assessment on AMU, AMR, GBPs and BMBs)**

- Depending on the results of the survey from Focus Area 1, Stage 1:
- Assess the risks for AMR
- Verify application of GBPs and BMBs
- Review nationally available guidelines on AMR, GBPs and BMBs considering international documents/literature
- Plan small-scale initiatives on proper AMU in beekeeping, GBPs and BMBs
- Evaluate laboratory results on diagnosis of honeybee diseases
- Evaluate results of AMR studies

**STAGE 2**
**(promotion of proper AMU, GBPs and BMBs at local/ provincial/small-scale level)**

- Implement small-scale initiatives on validated GBPs/ BMBs and on prudent and responsible use of antimicrobials in apiculture
- Implement an inspections/rewards and sanctions procedure concerning proper AMU and application of GBPs and BMBs at local/provincial level

**STAGE 3**
**(nationwide implementation of National Biosecurity Management Plan (NBMP) on AMU in beekeeping)**

- Implement a NBMP, including a national operational plan on AMU in beekeeping and adoption of GBPs and BMBs
- Implement integrated strategies to prevent and control honeybee diseases
- Implement nationally agreed initiatives and actions to foster proper AMU in beekeeping (including promotion of GBPs and BMBs)
- Develop a Sustainable National Biosecurity Management Plan (SNBMP)

**STAGE 4**
**(nationwide implementation of SNBMP, including operational plan on AMU)**

- Implement a SNBMP, including operational plan on AMR in beekeeping
- Develop reports regularly
- Make guidelines for proper AMU available in all sectors

# Chapter 6
# Conclusion

Over the past decade, the number of managed beehives around the world has increased by over 21 percent. As such, the need to establish international guidelines to ensure hives are managed correctly and prevent the spread of honeybee diseases has never been greater. Varroosis, American foulbrood, European foulbrood and nosemosis are just a few of the widespread diseases that pose a threat not only to colony health, but also to the producers and consumers that rely on bee products. Managing these diseases is one of the most challenging aspects of beekeeping and involves beekeepers, veterinarians and other professionals within the sector. All too often, beekeepers rely on veterinary medicines and antimicrobials, but in an era of sustainability, it is important to strive towards a One Health approach. To achieve this, various measures including GBPs and BMBs can be adopted, based on the principle that prevention is better than cure.

These guidelines include specific measures for the prevention of each disease to support beekeepers in this undertaking. Given that the use of antimicrobials within the beekeeping industry is not regulated in every country, some may be inclined to misuse or overuse medicinal treatments, a growing concern in multiple sectors. However, proper daily management, scheduled inspections and biosecurity measures reduce the need for therapeutical intervention. With the advent of two progressive management pathways in beekeeping (the PMP-BMB and PMP-AMR), all beekeepers and producers can strive to reduce the use of antimicrobials, decreasing the risk of AMR and achieving sustainable biosecurity. The first pathway focuses on the implementation of GBPs and BMBs to reach a national sustainable status of production, while the second tackles a multisectoral problem, highlighting the strategies required to adopt prudent or limited use of antibiotics, with the aim of diminishing the threat of AMR. Like the current guidelines, these comprehensive guidelines aim to inform beekeepers of the risks associated with poor management and incorrect antibiotic use, equipping them with the tools (namely a list of internationally approved GBPs and BMBs, and two PMPs with related surveys for risk assessment of AMU and disease management) to keep bees and produce bee products sustainably, while safeguarding the health of all.

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# Glossary

**Absconding swarm**
An entire colony of bees that abandons the hive due to disease, wax moths, excessive heat or water or lack of resources, among other reasons.

**Acarapis woodi**
An internal parasite that lives and reproduces inside honeybees. The mites parasitize young bees up to two weeks old via the tracheal tube. They pierce the tracheal tube walls with their mouthparts and feed on the haemolymph of the bees.

**AFB**
See "American foulbrood".

**American foulbrood (AFB)**
A highly infectious honeybee brood disease caused by the spore-forming bacterium, *Paenibacillus larvae.* The spore stage of the bacterium can remain viable for many years, making is difficult to eliminate the disease. Infected broods usually die at the prepupal or pupal stage. Heavy infections can affect most of the brood, severely weakening the colony and eventually killing it. It is the most widespread and destructive of the bee brood diseases.

**AMR**
See "antimicrobial resistance".

**Antimicrobial**
A naturally occurring, semi-synthetic or synthetic substance that kills or inhibits the replication of microorganisms

**Antimicrobial resistance (AMR)**
The inherited or acquired characteristic of microorganisms to survive or proliferate in concentrations of an antimicrobial that would otherwise kill or inhibit them.

**Apiary**
A site housing colonies of bees or beehives for beekeeping purposes. Also known as a "bee yard".

**Apiculture**
The science and art of raising honeybees.

**Apis mellifera**
Genus and species of the Western honeybee originating in Europe and Africa but now found around the world.

**Bee bread**
A mixture of collected pollen and nectar or honey stored in the cells of a comb as food. Bee bread is the primary pollen source for bees and is used especially by nurse bees to feed the young larvae.

**Bee brush**
A brush or whisk broom used to gently remove bees from combs.

**Bee escape**
A device used to remove bees from honey supers or buildings, permitting bees to pass through one way but not the other.

**Bee glue**
See "propolis".

**Beehive**
An enclosed, man-made structure (a box or receptacle) with movable frames, used for housing a colony of honeybee species of the subgenus Apis.

**Bee metamorphosis**
The three stages through which a bee passes before reaching the final adult anatomy of the bee – egg, larva and pupa.

**Bee space**
A space of less than 9.5 mm between combs and hive parts in which bees build no comb or deposit only a small amount of propolis. Bee spaces are used by the bees as corridors to move around the hive.

**Beeswax**
A mixture of organic compounds secreted by four pairs of special glands on the worker bees' abdomen and used for building combs.

**Bee veil**
A cloth or form of hat usually made of wire netting to protect the beekeeper's head and neck from stings.

**Bee venom**
The poison secreted by special glands attached to the stinger of the bee.

**Benchmarking**
Comparing the use of individual end users to the global use of all end users within the same sector, to identify excessive use.

**Biosecurity**
A strategic and integrated approach to analysing and managing relevant risks to human, animal and plant life and health and associated risks for the environment. It is based on recognition of the critical linkages between sectors and the potential for hazards to move within and between sectors, with system-wide consequences. European Regulation 2016/429 (European Parliament and European Council, 2016) defines "biosecurity" as the sum of management and physical measures designed to reduce the risk of the introduction, development and spread of diseases to, from and within: (a) an animal population, or (b) an establishment, zone, compartment, means of transport or any other facilities, premises or location.

**Biosecurity measures in beekeeping (BMBs)**
All the measures implemented to reduce the risk of introduction and spread of specific honeybee disease agents.

**BMBs**
See "biosecurity measures in beekeeping".

**Bottom board**
The floor of a beehive, which can be solid or mesh.

**Brace comb**
A small piece of wax built between two combs or frames to fasten them together. Brace comb is also built between a comb and adjacent wood, or between two wooden components such as top bars.

**Braula coeca**
The scientific name of a wingless fly commonly known as the bee louse. It is not a true bee parasite and resembles a spherical mite.

**Brood**
Immature bees in a state of metamorphosis which have not yet emerged from their cells. Brood can be in the form of eggs, larvae, or pupae at different ages.

**Brood chamber**
The part of the hive in which the brood is reared; it may include one or more hive bodies and the combs within them.

**Capped brood**
Pupae whose cells and cocoons have been sealed with a porous cover by adult bees. Also called "sealed brood".

**Cappings**
A thin layer of wax used to cover the full cells of honey. This layer of wax is sliced from the surface of a honey-filled comb to extract the underlying honey.

**Cascade prescription**
Veterinary medicines which are authorized for use for specific target species under specific conditions, based on assessed data.[7]

**Castes**
A term used to describe social insects of the same species and sex that differ in morphology or behaviour. In honeybees there are two castes: workers and queens (drones are a different sex and are therefore not included).

**Cell**
The hexagonal compartment of a comb built by honeybees.

**Chunk honey**
A combination of extracted and comb honey. The honey is cut from frames and placed in jars along with liquid honey.

**Clarifying**
Removing visible foreign material from honey or wax to increase its purity.

**Cluster**
A large group of bees hanging together, one upon another.

[7] For example, in the European Union (EU) region, Member States' veterinarians are permitted to use their clinical judgement to treat animals under their care where there is no suitable veterinary medicine authorized for the specific condition of the animal being treated, particularly to avoid unacceptable suffering (European Parliament and European Council. 2001. *Directive 2001/82/EC of the European Parliament and of the Council of 6 November 2001 on the Community code relating to veterinary medicinal products* [online]. OJ L 311, 28.11.2001. [Cited 29 September 2020]. pp. 1–123. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32001L0082). The cascade is a risk-based decision tree. The steps, in descending order of suitability, are:

- a veterinary medicine authorized in the same EU Member State for use in another animal species, or for a different condition in the same species.

If there is no such product that is clinically suitable, either:

- a human medicine authorized in the same EU Member State, or
- a veterinary medicine not authorized in the same EU Member State but authorized in another EU Member State for use in any animal species.

If there is no such product that is suitable:

- a medicine prescribed by the veterinarian responsible for treating the animal and prepared especially on this occasion (known as an "extemporaneous preparation") by a veterinarian, or a pharmacist.
- The prescribing veterinarian is personally responsible for the choice of product. The prescription and use of the product remains the veterinarian's responsibility.

**Colony**
All the worker bees, drones, the queen and developing brood living together in one hive or other dwelling.

**Comb**
A mass of six-sided cells made by honeybees in which the brood is reared and honey and pollen are stored; composed of two opposing layers.

**Comb foundation**
A commercially made structure consisting of thin sheets of beeswax with the cell bases of worker cells embossed on both sides in the same manner as they are produced naturally by honeybees.

**Comb honey**
Honey intended for consumption, which is still contained within its original hexagonal-shaped beeswax cells, called "honeycomb". It is eaten as produced by honeybees and has received no processing, filtering, or other manipulation. It is produced either by cutting the comb from the frame or when the comb is built in special frames which allow for its easy removal.

**Creamed honey**
Honey which has crystallized under controlled conditions to produce a tiny crystal and a smooth texture. Often a starter or seed is used to help control the crystallization.

**Crystallization**
The formation of sugar crystals in honey. Synonymous with "granulation".

**Dextrose**
A form of glucose ("D-glucose"). One of the two principal sugars found in honey, which forms crystals during granulation.

**Dividing**
Spltting a colony to form two or more colonies.

**Division board feeder**
A wooden or plastic compartment that is hung in a hive like a frame containing food for bees.

**Drawn combs**
Cells which have been built out by honeybees from a foundation in a frame.

**Drifting of bees**
The failure of bees to return to their own hive. Drones and young bees tend to drift more than older bees and bees from small colonies tend to drift into larger colonies.

**Drone**
The male honeybee.

**Drone comb**
A comb with larger cells (measuring about four cells per 2.5 linear cm) that is used for drone rearing and honey storage.

**Drone layer**
A queen who is incapable of fertilizing eggs. As a result, all the brood produced are drones.

**Dysentery**
A condition of adult bees characterized by diarrhoea (may be caused by low-quality food, change in feeding, or nosemosis infection, among other factors).

**EFB**
See "European foulbrood".

**European foulbrood (EFB)**
A highly infectious honeybee brood disease caused by bacterium

**Melissococcus plutonius**
Larvae of all ages are susceptible to infection and become infected after ingesting food contaminated with the bacteria. The disease is characterized by patchy brood with uncapped brood cells where the dead or dying larvae appear curled upwards, and are brown or yellow, making the larvae appear "molten" in the cell. The incidence of European foulbrood is generally higher when the colony is under stress, which may be caused by hive movement, weather conditions such as rain and cold, or poor nutrition.

**Extracted honey**
Honey removed from the comb.

**Extractor**
A machine which removes honey from the cells of comb by centrifugal force.

**Fermentation**
The process of yeast utilizing sugar to produce alcohol. Matured honey typically does not have enough moisture for fermentation to occur.

**Fertile queen**
A queen that has been either naturally or artificially inseminated and can lay fertilized eggs.

**Field bees**
Worker bees that are generally two to three weeks old that work to collect nectar, pollen, water and propolis for the colony.

**Follower board**
A thin board the size of a frame that can be inserted into a hive to reduce the space available to the bees. This is done especially in colder periods of the year to help smaller colonies keep the brood nest warm. Also known as a "division board".

**Frame**
A piece of equipment made of either wood or plastic designed to hold the comb.

**Fructose**
The predominant simple sugar found in honey.

**Fumagilin**
An antibiotic used to control nosemosis. This antimicrobial agent was isolated in 1949 from the fungus *Aspergillus fumigatus*.

**GBPs**
See "good beekeeping practices".

**GFPs**
See "good farming practices".

**Good beekeeping practices (GBPs)**
A collection of universally accepted best practices that beekeepers apply to their apiary production to attain optimal health of humans, honeybees and the environment.

**Good farming practices (GFPs)**
A collection of best practices applied in farming production and post-production processes, resulting in safe and healthy food and non-food agriculture products, taking into account economic, social and environmental sustainability.

**Glucose**
See "Dextrose."

**Grafting**
Removing a worker larva from its cell and placing it in a queen cup in order to have it reared into a queen.

**Grafting tool**
A needle or probe designed for transferring larvae from worker cells to a queen cell.

**Granulation**
The formation of sugar crystals in honey which may cause it to turn semi-solid.

**Hive**
The structure inside which bees reside.

**Hive body**
A wooden box that encloses the frames and is usually used as a brood chamber.

**Hive stand**
A structure that supports the hive.

**Hive tool**
A multi-use tool (often made from metal) used to open and inspect hives and frames.

**Honey**
A natural food produced by bees from the nectar of flowers, composed largely of a mixture of sugars. It contains about 17 percent water and small amounts of mineral matter, vitamins, proteins and enzymes.

**Honeydew**
A type of honey produced by the bees that collect the sugar excreted by aphids, leaflhoppers and some scale insects.

**Honey flow**
A term indicating that one or more major nectar sources are in bloom and the weather is favourable for bees to fly and collect the nectar in abundance.

**Honey house**
A building used for extracting honey and storing equipment.

**Honey stomach**
A specially evolved organ in the abdomen of the honeybee (also known as the "crop") used for carrying nectar, honey or water.

**Inner cover**
A light board that provides bees with sufficient space at the top of the hive body and good air circulation within the hive. It sits on top of the topmost hive body (the "super") and underneath the top cover.

**Larva (plural: larvae)**
The second stage of bee metamorphosis. The bee larva is a legless and featureless white grub. At this stage, its main purpose is to eat, and it never leaves the individual wax cell.

**Laying worker**
A worker bee that lays unfertilized eggs, producing only drones, usually in colonies that are queenless.

**Mating flight**
The flight taken by a virgin queen while she mates in the air with several drones.

**Migratory beekeeping**
The moving of colonies of bees from one locality to another during the beekeeping active season to take advantage of the honey flows.

**Nectar**
A sweet and often fragrant liquid secreted by the nectaries of plants. It is the raw product of honey.

**Nectar flow**
A time when nectar is plentiful and bees are able to produce and store honey.

**Nectaries**
The glands of plants which secrete nectar, located within the flower ("floral nectaries") or on leaves or stems ("extra-floral nectaries").

**Nosema**
Spore-forming parasitic protozoans (*Nosema apis, Nosema ceranae*) that affect honeybees, causing the disease nosemosis (or "*Nosema* disease").

**Nosemosis**
Disease of adult bees caused by the microsporidian *Nosema* spp. *Nosema apis* or *Nosema ceranae* are responsible for varying degrees of honeybee depopulation. The pathogen affects the gut of the bee and may result in malnutrition, dysentery and/or death.

**Nucleus**
A hive of bees which consists of fewer frames than a typical hive. A nucleus usually consists of two to five frames of comb and is used primarily for starting new colonies or rearing or storing queens; also shortened to "nuc".

**Nurse bees**
Young bees, three to ten days old, which feed and take care of developing brood.

**Observation hive**
A hive made largely of glass to allow bees to be observed.

**OTC**
See "oxytetracycline".

**Oxytetracycline (OTC)**
A broad-spectrum antibiotic, active against a wide variety of bacteria. It works by interfering with the ability of bacteria to produce essential proteins. Without these proteins, the bacteria cannot grow, multiply and increase in numbers. Oxytetracycline is not effective against the spores of *Paenibacillus larvae*, responsible for causing American foulbrood. Moreover, some strains of bacteria have developed resistance to this antibiotic, which has reduced its effectiveness for treating certain types of infection.

**Package bees**
A quantity of adult bees (usually 1–2 kg), with or without a queen, contained in a screened shipping cage with or without a source of food and/or water.

**Partial shook swarm**
Shaking the hives from brood combs into a clean hive with new foundations. Old store combs are left.

**Paenibacillus larvae**
Gram-positive, spore-forming bacterium that causes American foulbrood in honeybees.

**Paradichlorobenzene (PDF)**
Crystals used to fumigate stored combs against wax moth (*Galleria mellonella* or *Achroia grisella*).

**PDF**
See "paradichlorobenzene".

**Pheromones**
Chemical substances secreted from glands and used as a means of communication. Honeybees secrete many different pheromones.

**Play flight**
The short flight taken in front of or near the hive to acquaint young bees with their immediate surroundings.

**PMP**
See "Progressive Management Pathway".

**Pollen**
The male reproductive cell bodies produced by anthers of flowers. It is collected and used by honeybees as their source of protein, especially administered to the young larvae as feed.

**Pollen basket**
A flattened depression surrounded by curved hairs located on the outer surface of a bee's hind legs, allowing pollen to be transported from flowers to the hive.

**Pollen substitute**
Any material such as soybean flour, skim milk powder, brewer's yeast, or a mixture of these used in place of pollen as a source of protein to stimulate brood rearing. Sometimes used as a supplemental feed for the hive in early spring to encourage colony expansion.

**Pollen supplement**
A mixture of pollen and pollen substitutes used to stimulate brood rearing typically in early spring to encourage colony expansion.

**Pollen trap**
A device for removing pollen loads from the pollen baskets of incoming bees.

**Pollination**
The transfer of pollen from the anthers to the stigrna of flowers. Honeybees are excellent pollinators.

**Pollination service**
A service provided by beekeepers to farmers, who tap the resources of the beekeeper to improve their production yield.

**Primary swarm**
The first swarm to leave the parent colony, usually with the old queen (see "secondary swarm").

**Progressive Management Pathway (PMP)**
A tool to assist countries and farmers to put into place gradual and appropriate measures to improve the management of their production systems, for example, to decrease threats and risks, and improve hygiene.

**Propolis**
Resinous materials collected from gemmae of plants by bees and used to disinfect cells or to fill or seal empty spaces or cracks in the wood of hive or combs. Propolis is collected and processed as tinctures or additives to treat certain human ailments.

**Pupa**
The third stage of honeybee metamorphosis, during which it changes ("pupates") from a larva into an adult bee.

**Queen**
A female bee with a fully developed reproductive system. She is larger and longer than a worker bee.

**Queen cage**
A small cage in which a queen is confined for shipping (in this case, three to five worker bees are placed in the cage with the queen) or for brood interruption purposes (for example, to increase efficacy of oxalic acid based Varroa treatments).

**Queen cell**
A special elongated cell in which the queen is reared. It is more than 2.5 cm long and hangs vertically from the comb.

**Queen clipping**
Removing of a portion of (one or both) front wings of a queen to prevent her from flying to swarm.

**Queen excluder**
Metal or plastic barrier with openings that permit the passage of workers but restrict the movement of drones and queens to a specific part of the hive (usually the supers).

**Residues**
Traces of pesticides or other chemicals (medicines, hormones) in finished food or cosmetic products for consumer use.

**Robbing**
Stealing of nectar, or honey, by bees from other colonies. It happens more often during a nectar dearth and is a significant vector for transmission of honeybee diseases.

**Royal jelly**
A highly nutritious hive product secreted in the glands of young bees, used to feed the queen and larvae.

**Sacbrood virus**
A disease which affects the larva of honeybees caused by the Morator aetatulas virus.

**Scout bees**
Worker bees searching for a new source of pollen, nectar, propolis, water or a new home for a swarm of bees.

**Secondary swarm**
A smaller swarm which may occur after the primary swarm has occurred.

**Shook swarm method**
Consists of shaking the hives from the infected combs into a clean hive with new foundations.

**Smoker**
Device in which materials are slowly burned to produce smoke (not flames) which is used to subdue bees. A material that produces a cool smoke should be used so as not to harm the bees.

**Solar wax melter**
A glass-covered insulated box used to melt wax from combs and cappings with the heat of the sun.

**Stinger**
Appendage of the bee's abdomen which delivers the venom that the bee produces using its venom gland. A modified egg depositor used by the worker bees and by the queens as a weapon of defence and offence.

**Sucrose**
The main sugar found in nectar.

**Super**
Any hive body, or smaller box, used for the storage of surplus honey which a beekeeper can harvest. It is usually placed over or above the brood chamber and separated by a queen excluder (see "queen excluder"). There are several different dimensions of super available: shallow, medium and deep.

**Supersedure**
The natural replacement of an established queen by a newly reared queen from the same hive.

**Surplus honey**
Honey removed from the hive which exceeds that needed by bees for their own use (for example, to store as food to use during winter).

**Sustainable Development Goals**
The United Nations blueprint for achieving a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. The *Sustainable Development Goals* are a universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere. The 17 Goals were adopted by all United Nations Member States in 2015, as part of the *2030 Agenda for Sustainable Development,* which set out a 15-year plan to achieve the Goals. The Goals are interconnected and are designed to leave no one behind.

**Swarm**
A group consisting of many worker bees, drones and the old queen that leave the parent colony to establish a new colony.

**Swarming**
The natural process of propagating a colony of honeybees.

**Swarm cell**
Queen cells usually found on the bottom of the combs before swarming.

**Uncapping knife**
A knife used to shave or remove the cappings from combs of sealed honey prior to extraction. Uncapping of drone brood may be used to determine Varroa infestation levels.

**Uniting**
Combining two or more colonies to form one larger colony.

**Virgin queen**
A queen that has not mated.

**Wax foundation**
A wax plate forming the base of one honeycomb, also known as a "honeycomb base". It is used in beekeeping to give the bees a foundation upon which they can build the honeycomb.

**Wax glands**
Glands that secrete beeswax, pairs of which are present on the underside of the honeybees' last four abdominal segments.

**Wax moth**
Larvae of the moth *Galleria mellonella* or *Achroia grisella,* which can affect brood and empty combs of weak or abandoned colonies.

**Winter cluster**
A ball-like arrangement of adult bees within the hive during winter to increase their temperature.

**Worker bee**
A female bee whose reproductive organs are undeveloped. The majority of honeybees are worker bees, and they do all the work in the colony except for laying fertile eggs and mating with the queens.

## Annex 1

# Good beekeeping practices (GBPs)

TABLE 1
**Good beekeeping practices (GBPs)**

| 1. General apiary management | Mean score (1-4) | Category |
|---|---|---|
| Comply with legal obligations concerning restrictions on animal movements in cases of notifiable diseases | 4.0 | HBH |
| Only use bees and brood combs from healthy colonies (inspected and declared free of bee diseases) for nuclei | 3.8 | HBH |
| Respect hygiene rules (e.g. periodic cleaning of suits, gloves, etc.) | 3.8 | HBH |
| Only transport/move healthy colonies | 3.8 | HBH |
| Practice good hygiene when dealing with dead colonies (combs, food stores, boxes, etc.) | 3.8 | HBH |
| Disinfect levers and other potentially contaminated equipment (e.g. gloves) after inspection of hives affected by transmissible diseases | 3.7 | HBH |
| Balance colony strength among colonies by only transferring frames from healthy hives | 3.7 | HBH, PR |
| Avoid transporting hives during the warmer hours of the day, and provide adequate openings to enable sufficient air circulation in the hives | 3.7 | HBH |
| Practice hive management according to region, season and strength of colony | 3.7 | PR |
| Do not place honey supers directly on the ground (avoid contamination with *Clostridium botulinum*) | 3.7 | PS |
| Only purchase new bee colonies after they have been thoroughly inspected for bee diseases, preferably with a health certificate from a veterinarian | 3.6 | HBH |
| Replace the queens at least every two or three years, except for those of high genetic value | 3.6 | HBH, PR |
| Avoid contact with dust during the transport of the supers from the apiary to the honey house | 3.6 | PS |
| Only keep healthy strong colonies in the apiary | 3.5 | HBH, PR |
| Do not place beehives directly on the ground | 3.3 | PS |
| Evaluate the melliferous and pollen capacity of the area and the availability of water resources | 3.3 | HBH |
| Use disposable gloves when handling diseased hives | 3.3 | HBH |
| Have the support of an expert (e.g. a veterinarian or technician) to provide assistance in case of need | 3.3 | PR, HBH, PS |
| Avoid placing apiaries in areas with environmental pollutants (e.g. pesticides, heavy metals, etc.) | 3.2 | HBH |
| Do not abandon beekeeping materials in the apiary | 3.2 | PS |
| Maintain the balance between the number of nurse bees and brood when equalizing the hives; preferably use combs with hatching bees to fortify weak colonies | 3.2 | PR, HBH |
| Maintain a good balance between the number of hives and the amount of melliferous plants/ pollen sources in the area where the apiary is located | 3.1 | PR |
| Prevent swarming by inserting new wax foundations | 3.1 | HBH |
| Avoid placing apiaries in windy areas | 3.0 | HBH |
| Perform genetic selection in order to have queens that are more resistant to diseases and adapted to local climatic conditions | 3.0 | HBH |
| Place apiaries in an accessible area | 3.0 | HBH |
| Comply with the planned schedule for beehive inspections | 3.0 | PR |
| Prevent swarming through colony splitting | 3.0 | PR |
| Before winter, reduce the empty space in the hive | 3.0 | PR |
| Adjust the number of hives in the apiary according to the season, and to pollen, nectar and honeydew resources | 3.0 | HBH, PR |
| Adjust the number of hives within a flight range according to the season, and to pollen, nectar and honeydew resources | 3.0 | HBH, PR |

*(Cont)*

| 1. General apiary management | Mean score (1-4) | Category |
|---|---|---|
| Wintering: reduce the size of the hive entrance | 3.0 | HBH |
| Keep newly introduced colonies separate from the existing stock for an appropriate period (at least 1 month) to facilitate disease monitoring in order to prevent transmission | 2.9 | HBH |
| Avoid, as far as possible, the introduction of swarms of unknown origin, or colonies or queens from other apiaries | 2.8 | HBH |
| Place apiaries in a sturdy area | 2.8 | HBH |
| Reduce the opening of the hive entrance during robbing and cold periods and increase the opening of the hive entrance during the hot season | 2.8 | HBH |
| Use personal protective clothing and equipment when visiting honeybee colonies | 2.8 | HH |
| Keep purchased or weak colonies in a quarantine apiary | 2.8 | PR |
| Prevent swarming by using supers | 2.8 | PR |
| Prevent swarming by removing the entrance reducer | 2.8 | HBH, PR |
| Prevent swarming by genetically selecting the queens | 2.8 | PR |
| Use a queen excluder | 2.8 | HBH |
| Wintering: perform hive box maintenance (replace parts or paint them, check the integrity of hive boxes, if necessary) | 2.8 | PR |
| Place apiaries in an area accessible to vehicles | 2.7 | HBH |
| Prevent drift occurrence: avoid keeping too many colonies in a single row | 2.7 | HBH |
| Mark the queen bee according to the date of birth | 2.7 | PR, HBH |
| Perform regular maintenance of hives and fix broken hives that have unintentional openings to prevent robbing | 2.6 | HBH |
| Avoid areas where toxic plants (e.g. plants with pyrrolizidine alkaloids, *Echium spp.*, *Eupatorium spp.* and *Senecio spp.*) can be found in a significant quantity | 2.5 | PR |
| Position hive entrances where they can be reached with direct sunlight from the early morning hours | 2.5 | PS |
| Wintering: Verify the external position of the frames with stores in the hive | 2.5 | PR |
| During apiary inspections, ensure that corticosteroids or other proper medicines are readily available to protect the health and safety of the operators (for example, in case of anaphylaxis) | 2.4 | HH |
| Limit the amount of weight lifted (e.g. when harvesting supers or when moving hives) and, if necessary, use back protectors | 2.3 | HH |
| Wintering: reduce the number of frames in the hive box | 2.3 | PR |
| Wintering: insert a divider board to reduce the space available for the hive nest | 2.3 | PR |
| Prevent drift occurrence: paint/draw numbers or identification symbols on the front and entrance of the hive | 2.2 | HBH |
| Prevent swarming by inserting drawn combs | 2.2 | PR |
| Avoid areas where allergenic plants (e.g. *Ambrosia trifida* and *Artemisia vulgaris*) can be found in a significant quantity | 2.0 | PS |
| Indicate the age of the combs on the top bar of the frame (e.g. the year of insertion of the frame with the foundation) | 1.6 | HBH |
| Reduce bee stress (e.g. avoid unnecessary winter inspections of the hives; limit the use of smokers; feed the bees properly, etc.) | 1.3 | PR, HBH |
| Wintering: wrap the hive in black tar paper, if necessary | 1.3 | PR |
| Prevent swarming by removing the beehive's bottom board | 1.2 | PR |
| Provide adequate openings in the hive for air circulation, if necessary | 1.2 | PR, HBH |

TABLE 2
**Good beekeeping practices (GBPs)**

| 2. Veterinary Medicines | Mean score (1-4) | Category |
|---|---|---|
| Only use veterinary medicines registered for use in honeybees in your country or legally imported medicines | 4.0 | HH, HBH, PS |
| Ensure that all treatments or procedures are carried out correctly as described in the instructions (respecting dosage and method of application) | 4.0 | HH, HBH, PS |
| Do not use illegal treatments | 4.0 | HH, HBH, PS |

*(Cont)*

| 2. Veterinary Medicines | Mean score (1-4) | Category |
|---|---|---|
| Only use veterinary medicines registered for beekeeping use, follow the use instructions and record the treatments | 4.0 | HH, HBH, PS |
| Observe the withdrawal period of veterinary medicines and ensure that products from treated hives are not used for human consumption until the withdrawal periods have elapsed | 4.0 | PS, HH |
| If using instruments for the application (e.g. formic acid dispensers or oxalic acid sublimators) ensure that they are appropriate and correctly calibrated for the administration | 3.7 | HH, HBH, PS |
| Respect the required storage conditions for veterinary medicines and feed | 3.6 | PS, HBH |
| Dispose of used instruments and devices in a biosecure manner | 3.5 | HH, HBH |

TABLE 3
**Good beekeeping practices (GBPs)**

| 3. Disease Management | Mean score (1-4) | Category |
|---|---|---|
| In case of notifiable diseases, follow the instructions provided in the veterinary regulations and by the competent authorities | 4.0 | HBH |
| In case of infectious diseases, clean all beekeeping material between uses (e.g. hive bodies, hive bottom boards, feeders, hive tools) | 4.0 | HBH, PR |
| In case of infectious diseases, clean or disinfect the hive box before installing new colonies | 4.0 | HBH, PR |
| Carry out thorough inspections for clinical symptoms of bee diseases and the presence of the queen in spring | 3.8 | HBH, PR |
| Carry out thorough inspections for clinical symptoms of bee diseases and the presence of the queen at the end of the beekeeping season | 3.8 | HBH, PR |
| Quickly remove beehives housing dead colonies | 3.8 | HBH |
| Take samples for laboratory analysis when sick or dead bees are found, if necessary | 3.8 | HBH (Subcategory "Pre-clinica; Indicator" – PCI) |
| Regularly clean equipment and scrape off wax and propolis | 3.8 | HBH |
| Remove and process wax of all combs from dead, affected colonies | 3.7 | HBH, PR |
| Record the health status of the colonies: diseased/infected colonies (dates, diagnoses, ID of colonies affected, treatments and results) | 3.6 | PS, HBH |
| Renew 30 percent of the hive combs every year | 3.5 | HBH, PR |
| Record the health status of the colonies: mortality (dates, diagnoses, ID of colonies affected) | 3.4 | HBH |
| Promptly investigate any symptom of disease, asking a veterinarian (or a specialist) | 3.3 | HBH (Subcategory "Pre-clinica; Indicator" – PCI) |
| Do not move frames or any kind of biological material from one hive to another (e.g. to balance hives) if their health status is not well-known | 3.3 | HBH, PR |
| Only inspect diseased hives after healthy hive inspections are complete | 3.3 | HBH |
| Select best performing stocks of honeybees | 3.2 | HBH, PR |
| Burn dead colonies | 3.2 | HBH |
| Remove queens from colonies with a clinical history of American foulbrood disease | 3.0 | HBH, PR |
| Remove queens from colonies with a clinical history of European foulbrood disease | 3.0 | HBH, PR |
| Try to select and breed colonies that are more disease tolerant/resistant | 3.0 | HBH, PR |
| Record the origin and use of all disinfectants and consumable items used, keep records of the cleaning and disinfection procedures used on the equipment or the honey house (including data sheets for each detergent or disinfectant used) as well as records showing that these procedures have been effectively implemented (task sheets, self-inspection checks on the effectiveness of the operations) | 3.0 | PS, HBH, HH |
| Disinfect equipment (e.g. with NaOH or sodium hypochlorite) on a regular basis | 2.8 | HBH, PR |
| Carry out thorough inspections for clinical symptoms of bee diseases and the presence of the queen before supering the hives | 2.7 | HBH, PR |

TABLE 4
**Good beekeeping practices (GBPs)**

| 4. Hygiene | Mean score (1-4) | Category |
|---|---|---|
| Use torching (blue flame) to disinfect hives and beekeeping tools in case of transmissible diseases | 3.3 | HBH |
| Use bleaching (NaOH etc.) to disinfect hives and beekeeping tools in case of transmissible diseases | 3.2 | HBH |
| Incinerate the affected colony, if necessary, in case of transmissible diseases | 2.3 | HBH |
| Use heated (90°C), high-pressure water to disinfect hives and beekeeping tools in case of transmissible diseases | 1.6 | HBH |
| Use autoclaving to disinfect hives and beekeeping tools in case of transmissible diseases | 1.6 | HBH |
| Use gamma irradiation to disinfect beekeeping tools in case of transmissible diseases | 1.5 | HBH |

TABLE 5
**Good beekeeping practices (GBPs)**

| 5. Animal feeding and watering | Mean score (1-4) | Category |
|---|---|---|
| Do not feed the bees with honey, pollen or supplements unless the absence of pathogens (spores of American foulbrood, European foulbrood, chalkbrood, Nosema etc.) is certified | 4.0 | HBH |
| Provide bees with artificial feed when there is a shortage or to build up winter stores, when necessary | 3.7 | HBH, PR |
| Wintering: verify that there is a sufficient amount of stores in the hive | 3.7 | HBH |
| Provide nuclei and swarms with adequate food supply when necessary | 3.6 | HBH, PR |
| Ensure bees have access to safe water sources | 3.3 | HBH, PR |
| Do not feed your bees openly in the field to prevent robbing and spread of diseases | 3.3 | HBH, PR |
| Provide adequate water to the bees during transport, where necessary | 3.0 | HBH |

TABLE 6
**Good beekeeping practices (GBPs)**

| 6. Record-Keeping | Mean score (1-4) | Category |
|---|---|---|
| Keep records of veterinary medicine treatments | 4.0 | PS, HBH |
| Beekeepers must be registered with the National Beekeeping Registry | 3.8 | PS, HBH |
| Record the exact position of the bee yards | 3.8 | PS, HBH |
| Formally identify all the hives in each apiary with numbers/letters | 3.6 | PS, HBH |
| Keep records of honeybee diseases and colony mortality or depopulation | 3.5 | PS, HBH |
| Set up a data-recording system that can be used to trace exactly which batches of commercial feed the colonies were fed with | 3.5 | PS, HBH |
| Keep all documents/certificates about the commercial feed used | 3.5 | PS, HBH |
| For each colony or group of colonies, require and keep all commercial and health documents enabling their exact itinerary to be traced from their farm or establishment of origin to their final destination | 3.4 | PS, HBH |
| Record all reared colonies | 3.4 | PS, HBH |
| Record all colonies' arrivals, origin and date of arrival, to ensure that movements of incoming colonies are traceable to their source | 3.4 | PS, HBH |
| Keep records of movements of hives, swarms and queen bees | 3.4 | PS, HBH |
| Record period of collection of hive products from each apiary | 3.4 | PS |
| Keep detailed records of the origin and use of all medicines, including batch numbers, dates of administration, doses, treated hives and withdrawal times – treated hives or apiaries should be clearly identified | 3.3 | PS, HBH, HH |
| Keep all documents/certificates that indicate the raw materials used in feed manufactured by the beekeeper and given to the colonies | 3.3 | PS, HBH |
| Create a unique identification number for the apiary to easily trace the location of the hive (for stationary apiaries) | 3.2 | PS, HBH |
| Keep records of breeding activities (e.g. all breeding stock, queens' birth dates, their origin and arrival, the breeding dates in case of instrumental insemination and outcomes, etc.) | 3.2 | HBH |
| Establish a data-recording system to ascertain the exact origin (batch) of bee products produced | 3.2 | PS, HBH |
| Keep all the documents regarding self-inspections, official controls on the proper management of the colonies and the sanitary and hygienic quality of the bee products | 3.1 | PS |
| Keep all documents proving that the bacteriological and physico-chemical quality of the water used in the honey house, in feed preparation, or given to the colonies meets official tap water national standards | 3.0 | PS |
| Record the origin and use of all feed used, keep all records of any feed manufacturing procedures and records for each batch of feed | 2.9 | PS, HBH |
| Keep a list of certified suppliers | 2.8 | HBH |
| Record any other management changes that may occur | 2.5 | HBH |
| Record any change in feeding | 2.4 | PS, HBH |
| Keep all laboratory reports, including bacteriological tests and sensitivity tests | 2.4 | PS |
| Keep reference samples (-20°C) of all feed administered to the bees | 2.3 | PS, HBH |

TABLE 7
**Good beekeeping practices (GBPs)**

| 7. Training | Mean score (1-4) | Category |
|---|---|---|
| Obtain sufficient training/knowledge on honeybee diseases and signs | 3.5 | PS |
| Follow a training programme in beekeeping and honeybee diseases | 3.5 | HBH, |
| Attend personal training on beekeeping | 3.1 | HBH, PS, HH, PR |
| Keep datasheets recording each detergent/disinfectant used | 3.0 | HBH, PS, HH |
| Record disinfection procedures used | 3.0 | HBH, PS, HH |
| Keep a record of disinfection procedures that have been implemented | 3.0 | HBH, PS, HH |
| Keep the documents certifying the qualifications and training of people working with bees | 1.9 | PS |

List of categories
HBH: Honeybee health
HH: Human health
PCI: Preclinical indicators
PR: Productivity
PS: Product safety

Annex 2

# Biosecurity measures in beekeeping (BMBs)

TABLE 1

**Biosecurity measures in beekeeping (BMBs) for the most common honeybee diseases**

| **1. *Varroa destructor*** | **Mean score (1-4)** | **Category** |
|---|---|---|
| Always treat varroosis according to the national legislation and medicine registration | 4.0 | HBH, PS |
| Adopt/provide hives with screened bottom boards | 3.8 | HBH |
| Nuclei and swarms should originate from colonies with no clinical signs of diseases (American foulbrood, European foulbrood, deformed wing virus, sacbrood virus, etc.) | 3.8 | HBH, PR |
| Treat varroosis using an integrated pest management concept taking Varroa thresholds into account | 3.8 | HBH, PS, PR |
| Maintain the number of Varroa mites below the harmful threshold in each colony | 3.8 | HBH, PR, |
| Adopt diagnostic tools for measuring Varroa infestation levels (e.g. the icing sugar method, CO2 test, mite fall) after treatments and during the year (e.g.in spring at the beginning of the beekeeping season or before harvesting) | 3.8 | HBH, PCI |
| Simultaneously treat all colonies in the apiary and in the same area | 3.6 | HBH |
| Prepare your colonies before treatment to obtain optimal efficiency, depending on the type of treatment and product | 3.5 | HBH |
| Monitor efficacy of acaricide treatments: verify Varroa fall after treatment | 3.5 | HBH, PS, PR |
| Have good knowledge of the signs of varroosis and virosis | 3.4 | HBH, PR, |
| Perform at least two treatments per year | 3.3 | HBH |
| Monitor efficacy of acaricide treatments: verify the absence of varroosis signs in the colony (e.g. presence of Varroa mites on adult honeybees) after treatment | 3.2 | HBH, PR |
| Rotate active principles of veterinary medicines to avoid Varroa resistance | 3.2 | HBH, PR |
| Check the health status of drones producing colonies, especially for viruses | 3.2 | HBH, PR |
| Preferably use medicines allowed in organic farming to control Varroa | 3.1 | HBH, PS, PR |
| Provide sufficient number of healthy spare bee colonies, at the right time, depending on climate and vegetation conditions | 3.0 | HBH, PR |
| Have good knowledge of the ways in which varroosis and viruses are transmitted | 2.9 | HBH |
| Preferably use biological methods such as selection and breeding for Varroa-tolerant colonies, and Varroa-sensitive hygiene practices, etc. | 2.8 | HBH, PS, PR |
| Try to select and breed colonies that are more Varroa-tolerant/resistant | 2.8 | HBH, PR |
| Monitor efficacy of acaricide treatments: verify Varroa mite presence in the brood, after treatment | 2.7 | HBH, PR |
| Treat nuclei and swarms (no brood) with oxalic or lactic acid | 2.6 | HBH, PR |

TABLE 2

**Biosecurity measures in beekeeping (BMBs) for the most common honeybee diseases**

| **2. American Foulbrood (*Paenibacillus larvae;* AFB)** | **Mean score (1-4)** | **Category** |
|---|---|---|
| Perform the ropiness test to confirm clinical outbreak of AFB in the apiary | 4.0 | HBH |
| Quickly treat affected hives as an important measure to control the disease | 4.0 | HBH, PR |
| Check for *P. larvae* in asymptomatic colonies using laboratory tests (e.g. stored honey in combs, hive debris) to control the disease | 3.8 | HBH |
| Perform laboratory analysis (isolation and/or polymerase chain reaction [PCR] test) to confirm a clinical outbreak of AFB in the apiary | 3.7 | HBH |
| Melt down the combs of all colonies (with and without clinical signs) of the affected apiary and process wax safely to control the disease | 3.6 | HBH |

*(Cont)*

| 2. American Foulbrood (*Paenibacillus larvae;* AFB) | Mean score (1-4) | Category |
|---|---|---|
| Use AFB typical scales (not removable, firmly adherent to the cell wall) as an important method of confirming clinical outbreaks of AFB in the apiary | 3.3 | HBH |
| Only destroy hives that show clinical signs of AFB to successfully control the disease | 3.3 | HBH, PR |
| Disinfect/incinerate all beekeeping equipment (beehives, nucs, mating boxes, boards, frames, queen excluders, etc.) used for the whole apiary (AFB symptomatic and asymptomatic bees) in case of clinical outbreak of AFB to control the disease | 3.3 | HBH |
| Take samples from the colonies (hive debris/adult nurse bees/icing sugar/stores of honey in combs) during winter to detect *P. larvae* (with a PCR test or microbial isolation) in case of clinical outbreak to control the disease | 3.3 | HBH, PR, PCI |
| Thoroughly clean the honey-house extraction tools/facilities (uncappers, centrifuges, sieves, pumps, radial extractors, etc.) with detergent in case of clinical outbreak of AFB to control the disease | 3.1 | HBH |
| Thoroughly clean the hive-product packaging materials (jars, tanks, barrels, etc.) in case of clinical outbreak of AFB to control the disease | 3.0 | HBH |
| Disinfect/incinerate all beekeeping equipment (beehives, nucs, mating boxes, boards, frames, queen excluders, etc.) used in AFB symptomatic colonies only to control the disease | 2.7 | HBH |
| Only make shook swarms of hives that show clinical signs of AFB to control the disease | 2.5 | HBH, PR |
| Increase hive inspections in asymptomatic colonies (and in other apiaries belonging to the same beekeeper) to spot signs early and control the disease | 2.5 | HBH, PR |
| Use an AFB test (field kit) to confirm a clinical outbreak of AFB in the apiary | 2.4 | HBH |
| Make shook swarms of all colonies of the apiary (with and without clinical signs of AFB) to control the disease | 2.3 | HBH, PR |
| Only make partial shook swarms (only remove brood combs, leave store combs) of hives that show clinical signs of AFB to control the disease | 1.9 | HBH, PR |
| Stamp out (destroy) all colonies in the apiary (with and without clinical signs of AFB) to control the disease | 1.4 | HBH |
| Make partial shook swarms (remove only brood combs, leave store combs) of all colonies in the apiary (with and without clinical signs of AFB) to control the disease | 1.4 | HBH, PR |

TABLE 3
**Biosecurity measures in beekeeping (BMBs) for the most common honeybee diseas diseases**

| 3. European Foulbrood (*Melissococcus plutonius;* EFB) | Mean score (1-4) | Category |
|---|---|---|
| Quickly treat affected hives as an important measure to control the disease | 3.8 | HBH, PR |
| Check for visual clinical signs like removable scales, yellow and contorting larvae as an important way of confirming clinical outbreaks | 3.7 | HBH |
| Perform laboratory analysis (isolation and/or PCR test) to confirm a clinical outbreak of EFB in the apiary | 3.7 | HBH |
| Select queen breeders free of EFB | 3.6 | HBH, PR |
| Only make shook swarms of hives that show clinical signs of EFB to control the disease | 3.6 | HBH, PR |
| Disinfect/incinerate all beekeeping equipment (beehives, nucs, mating boxes, boards, frames, queen excluders, etc.) used in EFB symptomatic colonies only to control the disease | 3.5 | HBH |
| Increase hive inspections in symptomless colonies to control the disease | 3.4 | HBH |
| Only destroy hives that show clinical signs of EFB to control the disease | 2.8 | HBH |
| Take samples from the colonies (hive debris/adult nurse bees/icing sugar/stores of honey in combs) during winter to detect M. plutonius (with a PCR test or microbial isolation) in case of clinical outbreak to control the disease | 2.8 | HBH, PCI |
| Check for *M. plutonius* in asymptomatic colonies to control the disease | 2.6 | HBH |
| Thoroughly clean the honey-house extraction tools/facilities (uncappers, centrifuges, sieves, pumps, radial extractors, etc.) with detergent in case of clinical outbreak of EFB to control the disease | 2.6 | HBH |
| Use an EFB test (field kit) to confirm a clinical outbreak of EFB in the apiary | 2.5 | HBH |
| Only make partial shook swarms (only remove brood combs, leave store combs) of colonies that show clinical signs of EFB to control the disease | 2.4 | HBH, PR |
| Disinfect/incinerate all beekeeping equipment (beehives, nucs, mating boxes, boards, frames, queen excluders, etc.) used for the whole apiary (EFB symptomatic and asymptomatic bees) in case of clinical outbreak of EFB to control the disease | 2.3 | HBH |
| Thoroughly clean the hive-product packaging materials (jars, tanks, barrels, etc.) in case of clinical outbreak of AFB to control the disease | 2.3 | HBH |
| Pay attention to the odour when opening the hive – a typically sour smell can confirm a clinical outbreak of EFB | 2.1 | HBH |
| Make shook swarms of all colonies of the apiary (with and without clinical signs of EFB) to control the disease | 1.7 | HBH, PR |
| Make partial shook swarms (only remove brood combs, leave store combs) of all colonies of the apiary (with and without clinical signs of EFB) as a good measure to control the disease | 1.6 | HBH, PR |
| Stamp out (destroy) all colonies of the apiary (with and without clinical signs of EFB) as a good measure to control the disease | 1.3 | HBH |

TABLE 4
**Biosecurity measures in beekeeping (BMBs) for the most common honeybee diseas diseases**

| 4. Nosemosis (*N. apis, N. ceranae*) | Mean score (1-4) | Category |
|---|---|---|
| Keep artificial water sources free of faecal pollution and prevent drowned or dead bees | 3.7 | HBH, PR |
| Remove combs with signs of dysentery | 3.5 | HBH, PR |
| Take samples of forager honeybees (or use the icing sugar method or debris) early in autumn or spring to diagnose nosemosis (using a PCR test or a microscopic method) | 3.4 | HBH, PR, PCI |
| Adopt proper pathogen (e.g. Varroa) control procedures to ensure a proper balance in the composition of the bee colony (equilibrium of nurse–forager bees) | 3.2 | HBH, PR |
| Treat colonies where percentages of infected bees are higher than 40 percent, if there are any registered/permitted products in your country to treat *Nosema* spp. | 2.8 | HBH, PT, PS |
| Strengthen and stimulate the colonies in autumn and spring by administering stimulant integrators or feed supplements | 2.5 | HBH, PR |
| Select queen breeders with *Nosema* spp.-free stocks | 2.5 | HBH |
| Select and breed *Nosema* spp.-resistant honeybees | 2.5 | HBH |

List of categories
HBH: Honeybee health
HH: Human health
PCI: Preclinical indicators
PR: Productivity
PS: Product safety

Annex 3

# Risk assessment tools: the surveys

## ABOUT THE SURVEY

The model survey was developed and conducted by Appalachian State University as part of a European Union-funded project entitled BPRACTICES, with the technical support of the International Federation of Beekeepers' Associations (Apimondia), the Animal Production and Health Division of the Food and Agriculture Organization of the United Nations, and the Istituto Zooprofilattico Sperimentale del Lazio e della Toscana [Experimental Zooprophylactic Institute of Lazio and Tuscany]. All responses were anonymous to protect the respondents' personal information. The intent of the survey was to better understand beekeepers' knowledge of *Apis mellifera* (the honeybee) and the use of antibiotics around the world. The survey took between five and ten minutes to complete and thanked responders for their honesty and their time. The results were used to identify priorities for supporting beekeepers and making beekeeping more sustainable worldwide.

The contents of the survey are provided in this annex.

## INFORMED CONSENT

The study has been explained to me in a language that I understand. All the questions I had about the study have been answered.

I have been informed that it is my right to refuse to participate today and that if I choose to refuse I do not have to give a reason, and there will be no negative consequences for me.

I have been informed that anything I say during the discussion today will remain completely confidential: my name will not be used in any materials produced from this study, nor any other information that could be used to identify me. I have been informed that I can request access to, moderations to, and/or deletion of my personal data.

I give my consent to Appalachian State University and its employees to use my personal data as described above.

***Note:*** fields marked with asterisk offered multiple choices.

I agree to take part in this study

- ☐ Yes
- ☐ No

## DEMOGRAPHIC INFORMATION


1. Select the country in which you primarily house your bees*:

   ▾ Algeria ... New Zealand

2. Select the region of the country you selected in which you primarily house your bees:*
   ▾ Argentina, Northwest ... Wyoming

3. Year of birth*:
   ▾ 1920 ... Other

4. Select your gender:
   - ☐ Male
   - ☐ Female
   - ☐ Prefer not to answer

5. Select your **highest** education level:
   - ☐ High school (secondary) or less
   - ☐ Vocational or technical degree, associate degree, or some college
   - ☐ University degree
   - ☐ Postgraduate qualification

6. How many years have you been a beekeeper?*
   ▾ 0 ... 50

7. Estimate the number of hives you are currently managing:
   ______________________________________________

8. What type of hive do you use? (select all that apply)
   - ☐ Top bar hive
   - ☐ Langstroth hive
   - ☐ Warré hive
   - ☐ Dadant Blatt hive
   - ☐ Other(s) ______________________________________

9. Do you consider yourself a professional beekeeper?
   - ☐ Yes
   - ☐ No

10. Do you move your bees at all throughout the year?
    - ☐ Yes
    - ☐ No

11. How often do you inspect your hives **during the active season?** (Select the frequency closest to your situation)
    - ☐ Never
    - ☐ Once a month
    - ☐ Two to three times a month
    - ☐ Four times a month
    - ☐ More than four times a month

## KNOWLEDGE OF MAIN HONEYBEE DISEASES

1. Which of the following photos is an example of varroosis?
   - ☐ Image 1 (nosemosis)
   - ☐ Image 2 (AFB)
   - ☐ Image 3 (EFB)
   - ☐ Image 4 (varroosis)
   - ☐ Image 5 (chalkbrood)

2. Which of the following photos is an example of nosemosis?
   - ☐ Image 1 (nosemosis)
   - ☐ Image 2 (AFB)
   - ☐ Image 3 (EFB)
   - ☐ Image 4 (varroosis)
   - ☐ Image 5 (chalkbrood)

3. Which of the following photos is an example of American foulbrood?
   - ☐ Image 1 (nosemosis)
   - ☐ Image 2 (AFB)
   - ☐ Image 3 (EFB)
   - ☐ Image 4 (varroosis)
   - ☐ Image 5 (chalkbrood)

4. Which of the following photos is an example of European foulbrood?
   - ☐ Image 1 (nosemosis)
   - ☐ Image 2 (AFB)
   - ☐ Image 3 (EFB)
   - ☐ Image 4 (varroosis)
   - ☐ Image 5 (chalkbrood)

## 1. SURVEY ON VARROOSIS MANAGEMENT
### Beekeeping practices for varroosis

1. How knowledgeable are you about varroosis?
   - ☐ No knowledge
   - ☐ Little knowledge
   - ☐ Moderately knowledgeable
   - ☐ Very knowledgeable
   - ☐ Extremely knowledgeable

2. How experienced are you at recognizing varroosis?
   - ☐ Never seen it
   - ☐ Seen a live example of it
   - ☐ Seen it multiple times

3. Indicate how useful each of the following practices are in preventing/managing varroosis, according to your experience:

| | I don't know | Not at all useful | Moderately useful | Extremely useful |
|---|---|---|---|---|
| Adopting/providing hives with screened bottom boards | ☐ | ☐ | ☐ | ☐ |
| Sourcing nuclei and swarms from colonies with no clinical signs of diseases related to Varroa mites | ☐ | ☐ | ☐ | ☐ |
| Maintaining the number of Varroa mites below the harmful threshold in each colony | ☐ | ☐ | ☐ | ☐ |
| Adopting diagnostic tools for measuring Varroa mite infestation levels (for example, the icing sugar method, CO2 tests, mite fall etc.) after treatments and during the year (for example, in spring at the beginning of the beekeeping season or before harvesting) | ☐ | ☐ | ☐ | ☐ |
| Providing a sufficient number of healthy spare bees at the right time | ☐ | ☐ | ☐ | ☐ |

*(Cont)*

| | I don't know | Not at all useful | Moderately useful | Extremely useful |
|---|---|---|---|---|
| Having good knowledge of the signs of varroosis and virosis | ☐ | ☐ | ☐ | ☐ |
| Selecting and breeding queens that are more Varroa-tolerant/-resistant | ☐ | ☐ | ☐ | ☐ |
| Treating swarms (not broods) immediately after the harvest | ☐ | ☐ | ☐ | ☐ |

## Acaricides

4. Have you treated your bees with anti-varroosis medicine in the last two years?
   - ☐ Yes
   - ☐ No

5. List any anti-varroosis medicines that you regularly use: (if you don't know, leave this blank)
   ________________________________________

6. Where do you get the anti-varroosis medicines that you use? (select all that apply)
   - ☐ Agrochemical supply company
   - ☐ Veterinarian
   - ☐ Pharmacy
   - ☐ Other beekeepers
   - ☐ Beekeepers' association
   - ☐ Internet
   - ☐ Extension services
   - ☐ Other(s) (please explain) ______________________________

7. Do you normally need a prescription for anti-varroosis medicines?
   - ☐ Yes
   - ☐ No
   - ☐ It depends (please specify the conditions): ______________________________
   ________________________________________

8. If/when you use anti-varroosis medicines, how do you proceed?

| | Yes | No |
|---|---|---|
| Simultaneously treat all colonies in the apiary | ☐ | ☐ |
| Treat only the diseased hives in the apiary | ☐ | ☐ |
| Perform at least two treatments per year | ☐ | ☐ |
| Rotate the products | ☐ | ☐ |
| Preferably use medicines allowed in organic farming | ☐ | ☐ |
| Monitor efficacy of treatments: verify Varroa mite presence on adult bees after treatment | ☐ | ☐ |
| Monitor efficacy of treatments: verify Varroa mite presence on adult bees after treatment (for example, with the icing sugar method, alcohol wash, soapy water) | ☐ | ☐ |

9. How often do you think beekeepers use anti-varroosis medicines without following the instructions on the label?
   - ☐ Never
   - ☐ Sometimes
   - ☐ Often
   - ☐ Usually
   - ☐ Always

## 2. SURVEY ON INFECTIOUS DISEASE MANAGEMENT

1. How **knowledgeable** are you about the following bee diseases?

| | No knowledge | Little knowledge | Moderately knowledgeable | Very knowledgeable | Extremely knowledgeable |
|---|---|---|---|---|---|
| Nosemosis | ☐ | ☐ | ☐ | ☐ | ☐ |
| European foulbrood | ☐ | ☐ | ☐ | ☐ | ☐ |
| American foulbrood | ☐ | ☐ | ☐ | ☐ | ☐ |

2. How **experienced** are you at recognizing the following diseases?

| | Never seen it | Seen a live example of it | Seen it multiple times |
|---|---|---|---|
| Nosemosis | ☐ | ☐ | ☐ |
| American foulbrood | ☐ | ☐ | ☐ |
| European foulbrood | ☐ | ☐ | ☐ |

3. How **useful** is it to be able to recognize the signs of each of the following bee diseases?

| | Not at all useful | Slightly useful | Moderately useful | Very useful | Extremely useful |
|---|---|---|---|---|---|
| Nosemosis | ☐ | ☐ | ☐ | ☐ | ☐ |
| European foulbrood | ☐ | ☐ | ☐ | ☐ | ☐ |
| American foulbrood | ☐ | ☐ | ☐ | ☐ | ☐ |

### Beekeeping practices for nosemosis

1. Indicate how **useful** each of the following practices are in preventing/managing nosemosis, according to your experience:

| | Not useful | Slightly useful | Moderately useful | Very useful | Extremely useful |
|---|---|---|---|---|---|
| Removing combs that show signs of dysentery | ☐ | ☐ | ☐ | ☐ | ☐ |
| Taking samples of forager bees for diagnosis | ☐ | ☐ | ☐ | ☐ | ☐ |
| Taking samples of hive debris for diagnosis | ☐ | ☐ | ☐ | ☐ | ☐ |
| Treating bees for varroosis | ☐ | ☐ | ☐ | ☐ | ☐ |
| Feeding colonies | ☐ | ☐ | ☐ | ☐ | ☐ |
| Replacing the queen | ☐ | ☐ | ☐ | ☐ | ☐ |
| Treating bees with antibiotics | ☐ | ☐ | ☐ | ☐ | ☐ |

2. Indicate how **feasible** it would be to use the following practices in your beekeeping activities, according to your experience:

| | Not feasible | Slightly feasible | Moderately feasible | Very feasible | Extremely feasible |
|---|---|---|---|---|---|
| Removing combs that show signs of dysentery | ☐ | ☐ | ☐ | ☐ | ☐ |
| Taking samples of forager bees for diagnosis | ☐ | ☐ | ☐ | ☐ | ☐ |
| Taking samples of hive debris for diagnosis | ☐ | ☐ | ☐ | ☐ | ☐ |
| Treating bees for varroosis | ☐ | ☐ | ☐ | ☐ | ☐ |

*(Cont)*

| | Not feasible | Slightly feasible | Moderately feasible | Very feasible | Extremely feasible |
|---|---|---|---|---|---|
| Feeding colonies | ☐ | ☐ | ☐ | ☐ | ☐ |
| Replacing the queen | ☐ | ☐ | ☐ | ☐ | ☐ |
| Treating bees with antibiotics | ☐ | ☐ | ☐ | ☐ | ☐ |
| Removing combs that show signs of dysentery | ☐ | ☐ | ☐ | ☐ | ☐ |

### Beekeeping practices for American Foulbrood (AFB) and European Foulbrood (EFB)

1. Indicate how useful each of the following practices are in preventing/managing AFB/EFB, according to your experience:

| | Not useful | Slightly useful | Moderately useful | Very useful | Extremely useful |
|---|---|---|---|---|---|
| Inspecting hives more frequently to detect the disease earlier | ☐ | ☐ | ☐ | ☐ | ☐ |
| Taking note of the odour when opening the hive | ☐ | ☐ | ☐ | ☐ | ☐ |
| Performing a ropiness test to confirm clinical outbreaks of AFB | ☐ | ☐ | ☐ | ☐ | ☐ |
| Finding AFB and EFB typical scales | ☐ | ☐ | ☐ | ☐ | ☐ |
| Using commercial field kits for self-diagnosis | ☐ | ☐ | ☐ | ☐ | ☐ |
| Disinfecting or incinerating the infected bee tools, facilities and equipment | ☐ | ☐ | ☐ | ☐ | ☐ |
| Processing wax safely | ☐ | ☐ | ☐ | ☐ | ☐ |
| Monitoring the presence of the disease even in apparently healthy hives, sending samples to the laboratory as a preventive measure | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sending samples from hives showing signs of the disease to a laboratory | ☐ | ☐ | ☐ | ☐ | ☐ |
| Making a shook swarm from the infected hives (moving bees to fresh comb foundations and destroying the old combs) | ☐ | ☐ | ☐ | ☐ | ☐ |
| Making a shook swarm from the whole apiary | ☐ | ☐ | ☐ | ☐ | ☐ |
| Treating bees with antibiotics | ☐ | ☐ | ☐ | ☐ | ☐ |
| Destroying only infected colonies that show signs of the disease | ☐ | ☐ | ☐ | ☐ | ☐ |
| Destroying the whole apiary | ☐ | ☐ | ☐ | ☐ | ☐ |
| Quickly taking steps to manage the disease | ☐ | ☐ | ☐ | ☐ | ☐ |
| Selecting queen bees free of AFB/EFB | ☐ | ☐ | ☐ | ☐ | ☐ |

## 3. SURVEY ON ANTIBIOTIC RESISTANCE

1. What are antibiotics? (select all that apply)
   - ☐ Medicines that prevent diseases
   - ☐ Medicines that cure only some diseases
   - ☐ Medicines that kill or slow down the growth of bacteria and some other germs
   - ☐ Medicines that increase the production of hives
   - ☐ Other
   - ☐ I do not know

2. Have you treated your bees with antibiotics in the last two years?
   - ☐ Yes
   - ☐ No

3. List any medicines or treatments you regularly use in your apiary/apiaries (if you don't know, leave this blank).
   ________________________________________
   ________________________________________
   ________________________________________
   ________________________________________

4. Do you use antibiotics for any of the following? (select all that apply)
   - ☐ Nosemosis
   - ☐ Varroosis
   - ☐ American foulbrood
   - ☐ European foulbrood
   - ☐ Small hive beetle
   - ☐ None
   - ☐ Other(s), please explain ________________________________________
   ________________________________________

5. Where do you get your antibiotics? (select all that apply)
   - ☐ Agrochemical supply company
   - ☐ Veterinarian
   - ☐ Pharmacy
   - ☐ Other beekeepers
   - ☐ Beekeepers' association
   - ☐ Internet
   - ☐ Extension services
   - ☐ Other(s), please explain ________________________________________
   ________________________________________

6. Do you normally need a prescription for antibiotics?
   - ☐ Yes
   - ☐ No
   - ☐ It depends (please specify the conditions): ________________________________________
   ________________________________________

7. For which purpose(s) do you use antibiotics? (select all that apply)
   - ☐ Prevention of an infection
   - ☐ Treatment of an infection

8. Where do you obtain information on the use of antibiotics from? (select all that apply)
   - ☐ Agrochemical supply companies
   - ☐ Veterinarian
   - ☐ Pharmacy
   - ☐ Other beekeepers
   - ☐ Beekeepers' association
   - ☐ Internet
   - ☐ Books
   - ☐ Extension services
   - ☐ Other(s), please explain ________________________________________
   ________________________________________

9. How often do you think beekeepers use antibiotics without following the instructions on the label?
   - ☐ Never
   - ☐ Sometimes
   - ☐ Often
   - ☐ Usually
   - ☐ Always

10. How **knowledgeable** are you about antibiotics intended for use on bees?
   - ☐ No knowledge
   - ☐ Little knowledge
   - ☐ Somewhat knowledgeable
   - ☐ Moderately knowledgeable
   - ☐ Extremely knowledgeable

11. How much do you agree with the statement that "honey/honeycomb from bees just treated with antibiotics should not be consumed"?
   - ☐ Agree
   - ☐ Indifferent
   - ☐ Disagree

12. Do you know what "antibiotic residues" are?
   - ☐ Yes
   - ☐ No

13. Do you know what "drug-resistant infections" are?
   - ☐ Yes
   - ☐ No

14. How often do you see antibiotics fail to treat bees?
   - ☐ Never
   - ☐ Sometimes
   - ☐ Almost always
   - ☐ Always
   - ☐ Don't know

15. How much do you agree with the statement that "if medicines are used too often, they might stop working"?
   - ☐ Agree
   - ☐ Indifferent
   - ☐ Disagree

16. Has a veterinarian ever told you about the risks of either using medicines too often or using the wrong type of antibiotics?
   - ☐ Yes
   - ☐ No

17. How much do you believe drug-resistant infections will affect you, your family/friends and your bees?
   - ☐ No impact
   - ☐ A little impact
   - ☐ A large impact
   - ☐ I don't know about drug-resistant infections

18. How **experienced** are you at recognizing bees' resistance to medicines?
    - ☐ Never seen it
    - ☐ Seen a live example of it
    - ☐ Seen it multiple times

19. Drug-resistant infections

    When an infection strikes and medicines like antibiotics (and other antimicrobials) do not work, you can lose your entire stock of animals to disease. This also puts the health of you and your family at risk because disease can spread between animals and people. Save lives and livelihoods by following the advice below, starting today!

    There are two main reasons why antimicrobials do not cure an infection:

    - they are the wrong treatment or have been used improperly;
    - the germs causing the infection have become resistant to this treatment in a process called "antimicrobial resistance" (AMR).

Every time we use antimicrobials to treat infections in people, animals and plants, these germs have a chance to learn how to tolerate these treatments, making them less effective over time.

AMR is leading to the failure of our most important medicines. Without working antimicrobials, many more people, animals and plants are at risk of dying from infections.

## Training and interactions

1. Would you be interested in bee health training?
   - ☐ Yes
   - ☐ No

2. Would you be interested in an online training course?
   - ☐ Yes
   - ☐ No

3. Please list any professional beekeeping associations/groups related to bees that you belong to/know about.

   ______________________________________________________________

4. Please list any bee-specific training or courses that you have attended.

   ______________________________________________________________

5. How interested are you in a nationwide service connecting beekeepers with veterinary experts specialized in bees?
   - ☐ Not at all interested
   - ☐ Somewhat interested
   - ☐ Interested
   - ☐ Very interested
   - ☐ Extremely interested

6. If you are willing to be available for a few follow-up questions or more information, please leave your email address below.

   ______________________________________________________________

7. Share any additional comments.

   ______________________________________________________________

   ______________________________________________________________

8. This is the end of the survey. By clicking the next button, you're submitting the survey. Thank you for your response.

For more information: www.fao.org/antimicrobial-resistance
FAQ on antimicrobial resistance: www.fao.org/antimicrobial-resistance/background/faq/en/

**FAO ANIMAL PRODUCTION AND HEALTH GUIDELINES**

1. Collection of entomological baseline data for tsetse area-wide integrated pest management programmes, 2009 (En)
2. Preparation of national strategies and action plans for animal genetic resources, 2009 (En, Fr, Es, Ru, Zh)
3. Breeding strategies for sustainable management of animal genetic resources, 2010 (En, Fr, Es, Ru, Ar, Zh)
4. A value chain approach to animal diseases risk management – Technical foundations and practical framework for field application, 2011 (En, Zh, Fr**)
5. Guidelines for the preparation of livestock sector reviews, 2011 (En)
6. Developing the institutional framework for the management of animal genetic resources, 2011 (En, Fr, Es, Ru)
7. Surveying and monitoring of animal genetic resources, 2011 (En, Fr, Es)
8. Guide to good dairy farming practice, 2011 (En, Fr, Es, Ru, Ar, Zh, Pt[e])
9. Molecular genetic characterization of animal genetic resources, 2011 (En, Zh**)
10. Designing and implementing livestock value chain studies – A practical aid for Highly Pathogenic and Emerging Disease (HPED) control, 2012 (En)
11. Phenotypic characterization of animal genetic resources, 2012 (En, Fr[e], Zh[e])
12. Cryoconservation of animal genetic resources, 2012 (En)
13. Handbook on regulatory frameworks for the control and eradication of HPAI and other transboundary animal diseases – A guide to reviewing and developing the necessary policy, institutional and legal frameworks, 2013 (En)
14. *In vivo* conservation of animal genetic resources, 2013 (En, Zh**)
15. The feed analysis laboratory: establishment and quality control – Setting up a feed analysis laboratory, and implementing a quality assurance system compliant with ISO/IEC 17025:2005, 2013 (En)
16. Decision tools for family poultry development, 2014 (En)
17. Biosecurity guide for live poultry markets, 2015 (En, Fr[e], Zh[e], Vi)
18. Economic analysis of animal diseases, 2016 (En, Zh)
19. Development of integrated multipurpose animal recording systems, 2016 (En, Zh)
20. Farmer field schools for small-scale livestock producers – A guide for decision makers on improving livelihoods, 2018 (En, Fr[e])
21. Developing sustainable value chains for small-scale livestock producers, 2019 (En, Zh**)
22. Estimation des bilans fourragers dans la région du Sahel d’Afrique de l’Ouest et Centrale, 2020 (Fr)
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Availability: October 2021

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Multil – Multilingual
* Out of print
** In preparation
[e] E-publication

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**Office of Communications – November 2020**

*Responsible use of antimicrobials in beekeeping*

# Corrigendum

Updated on 17 March 2022

The following corrections were made to the PDF after it went to print.

| Page | Location | Text in printed PDF | Text in corrected PDF |
|---|---|---|---|
| i | bottom | Published by:<br>The Food and Agriculture Organization of the United Nations<br>and<br>Istituto Zooprofilattico Sperimentale del Lazio e della Toscana M. Aleandri<br>Rome, 2021 | Food and Agriculture Organization of the United Nations<br>Rome, 2021 |
| ii | Required citation | **FAO and IZSLT.** 2021. *Responsible use of antimicrobials in beekeeping*<br>FAO Animal Production and Health Guidelines No. 26. Rome. https://doi.org/10.4060/cb6918en | FAO and IZSLT. 2021. *Responsible use of antimicrobials in beekeeping*. FAO Animal Production and Health Guidelines No. 26. Rome, FAO. https://doi.org/10.4060/cb6918en |
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These guidelines focus on responsible use of antimicrobials in sustainable apiculture. With a One Health approach, applying these principles will protect not only human health, but even honeybee health (e.g. reducing the likelihood of residues in hive products and preventing development of antimicrobial resistance) and the health of the environment. The best way to reach this goal is to prevent honeybee diseases through the application of good beekeeping practices and biosecurity measures.

And when medicines are needed for the honeybees, specific recommendations are provided to reduce their impact: choosing medicines with a low environmental impact, using them a the correct time and duration, prudently and following the label instructions. It is imperative to apply only active ingredients that are registered for use in honeybees and ideally are prescribed by a veterinarian. Antibiotics should be avoided as much as possible to reduce risks of residues in hive products and to prevent risks of antimicrobial resistance.

Prudent and limited use of antimicrobials in beekeeping benefits the quality of bee products and the safety of surrounding ecosystems, while also slowing development of antimicrobial resistance, which is a widespread issue affecting multiple sectors. Finally, in this document, for the first time, a progressive management pathway (PMP) has been proposed for honeybees, as well as surveys to assess current beekeeping practices and general awareness of topical issues such as AMR. The overall aim of these guidelines is to provide information about current challenges within the sector and promote sustainable production and honeybee colony health.

ISBN 978-92-5-135005-8 ISSN 1810-0708

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CB6918EN/1/09.21