Chapter 11: Epidemiology and Biosecurity

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Honey bees serve a vital role in agriculture and food security both nationally and globally. However, their health can be negatively impacted by a variety of pathogens including viruses, bacteria, fungi, protozoa, and parasites. Like other social organisms, honey bees are at risk for pathogen transmission through numerous routes, and co-infections with multiple pathogens are not uncommon.

Disease management in honey bees requires a combination of best management practices that keep bees healthy, enhance disease resistance, and provides biosecurity to reduce disease exposure. Since honey bees are free ranging, it is not possible to completely exclude exposure to endemic diseases through biosecurity; however, a combination of good management practices and improved biosecurity can reduce the likelihood, and consequences, of infection in a colony. Knowledge and implementation of best management practices with an emphasis on good biosecurity is a beekeeper's best defense in protecting the health and vitality of their colonies.

This presents veterinarians with an opportunity to provide education and professional services to beekeepers, particularly hobbyists and sideline apiarists who often have less experience and could benefit from professional assistance. As food-producing animals, bees are considered livestock by the US Food and Drug Administration (FDA) as well as by the Food and Agriculture Organization (FAO) of the United Nations and by the World Organization for Animal Health (OIE). Indeed, FAO and OIE state that livestock owners should establish a working relationship with a veterinarian to ensure animal health and welfare as well as prompt identification and reporting of disease issues (OIE and FAO 2009; OIE 2014).

1.*Apis mellifera* Disease Epidemiology

Although not all inclusive, this chapter will focus on those pathogens of interest to *A. mellifera* that had the highest potential or actual impact on the US honey bee industry at the time of writing. Specific details on these and other honey bee diseases can be found in Section 3 of this text, as well as in separate Chapters 14, 15, and 16. The USDA Agricultural Research Service Bee Research Laboratory in Beltsville, MD, offers bee disease diagnostic services for the US and its territories. More detailed information on diagnostic sampling in honey bees can be found in Chapter 12.

Following large-scale, unexplained losses of managed US honey bee colonies during the winters of 2006-2007 and 2007-2008 (vanEngelsdorp et al. 2007, 2008), investigators identified the cause as a multifactorial, common set of clinical signs that were termed colony collapse disorder (CCD) (vanEngelsdorp et al. 2009). See Chapter 20 for a more detailed discussion of CCD. During 2009, in the aftermath of CCD, the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) began conducting the National Honey Bee Disease Survey (National Survey) to establish an epidemiologic honey bee disease baseline in the US and its territories and verify the absence of exotic threats to the honey bee. This annual survey, funded by USDA-APHIS and conducted in collaboration with the University of Maryland, USDA Agricultural Research Service (ARS), and State Apiary Specialists, has expanded from three participating states in 2009 to 38 states and territories in 2019 and represents the most comprehensive data set of US honey bee pest and health information to date (USDA-APHIS Honey Bee Pests and Diseases Survey Project Plan for 2019). All survey data, including historic and ongoing research, is incorporated into the nationwide Bee Informed Partnership (BIP) database. Results of the National Survey have and will continue to provide valuable insight into the epidemiology of honey bee diseases.

1.1 Exotic Diseases of Honey Bees

Longitudinal monitoring through the National Survey has continued to provide strong evidence for the absence of important exotic diseases of honey bees (*Tropilaelaps* spp., *Apis cerana*, and Slow Bee Paralysis Virus (SBPV)) in managed US honey bee colonies (USDA-APHIS Honey Bee Pests and Diseases Survey Project Plan for 2019). *Tropilaelaps* mites are an ectoparasite of immature stages of honey bees. Infestations are regulated worldwide for trade purposes and are reportable in uninfested regions, including the US (Vidal-Naquet 2015). *A. cerana*, or the Asian honey bee, has extended beyond its native range of southern Asia. It is considered an invasive species in many parts of the world because it serves as a natural host to both *Varroa* and *Nosema* spp. so could increase the spread of these parasites and also has the potential to compete with *A. mellifera* for nectar, pollen, nesting sites, and other vital resources (Plant Health Australia 2019; Egelie et al. 2015). Slow Bee Paralysis Virus causes paralysis of the forelegs of bees and is vectored by the *Varroa* mite which transmits the virus to both pupae and adult bees (Santillàn-Galicia et al. 2010). This virus has been linked to high mortality of colonies infested with the *Varroa* mite (Carreck et al. 2010; Martin et al 1998).

Absence of these potentially devastating exotic pathogens suggests that current methods to prevent their introduction into the US have been successful; however, continued vigilance is paramount to the protection of the honey bee industry.

1.2 *Varroa destructor*

The parasitic mite, *Varroa destructor,* is the greatest single threat to managed colonies of *A. mellifera* on a global scale (Rosenkranz 2010). Originally, *A. cerana* served as the natural host of the *Varroa* mite; however, during the middle of the 20^{th} century, *V. destructor* transferred to a new host, the honey bee *A. mellifera* (Vidal-Naquet 2015). *Varroa* are now ubiquitously present in US honey bee colonies and have a dramatic impact on honey bee health, not only due to the direct effects of their feeding on brood and adult bees but also their ability to serve as a vector of numerous viruses. According to samples collected by Fahey et al. through the 2016-2017 National Survey, the presence of *Varroa destructor* mites has remained relatively constant in survey samples since 2010, with an average of 90% of samples testing positive each year. The average load of *Varroa* peaked during the 2012-2013 survey year at 5.5 mites per 100 bees and has gradually decreased since that time, now averaging 3.3 mites per 100 bees. While *Varroa* load has decreased over time, there has been little to no change in prevalence. Possible explanations include the success of nationwide outreach and extension efforts targeting beekeepers regarding appropriate monitoring and treatment of *Varroa*. Alternatively, viruses vectored by *Varroa destructor* may have become more virulent, resulting in higher colony loss and thus a drop in mite populations. (Fahey et al. 2016-2017). See Chapter 18 on *Varroa.*

1.3 Nosemosis

Nosemosis, or nosema disease, can affect all three castes of honey bees and is caused by two species of spore-forming microsporidian parasites, *Nosema apis* and *Nosema ceranae* (Vidal-Naquet 2015). According to the 2016-2017 National Survey, *Nosema* spp. spore prevalence has remained historically consistent, being detected on average in 50% of samples. Similar to *Varroa destructor*, the average load of *Nosema* spp. has decreased over time in obtained samples while prevalence has remained about the same. It should be noted that in 2013, speciation of *Nosema apis* and *Nosema ceranae* was discontinued after no detections of *Nosema apis* from 2009-2010, detections of 1.3% in 2011, and 0.7% in 2012. Therefore, all *Nosema* counts since 2013 are attributed to *Nosema ceranae* (Fahey et al. 2016-2017). The average *Nosema* spore load during the 2016-2017 survey revealed 0.54 million spores per bee which is slightly lower than the previous 5 years of the survey where *Nosema* spore load averaged 0.66 million spores per bee. This trend will continue to be monitored through the survey in coming years to determine its significance to overall honey bee health. See Chapter 16 on Nosema.

1.4 Multi-year Disease Baseline

In addition to annual reports, endemic disease results from the 2009-2014 National Survey (including *Varroa destructor*, *Nosema* spp., and eight honey bee viruses) were assessed and quantified by Traynor et al (2015) providing a multi-year disease baseline to assist in identifying drivers of poor bee health. Several observations were made including the identification of significant differences in disease prevalence between migratory hives (those transported to different locations for pollination services) and stationary hives. Migratory beekeepers had significantly lower *Varroa* prevalence and loads than stationary colonies, while the opposite was seen with *Nosema* spp. which were more prevalent in migratory colonies. One hypothesis offered by the authors was that migratory beekeepers may be treating for mites more frequently or that the physical movement of transporting bees for pollination purposes may somehow interfere with mite reproduction. Seasonal differences were also noted in *Varroa destructor* and *Nosema* spp. loads. *Nosema* spore counts peaked annually in April, when colonies are often nutritionally stressed after the winter months and bees may be confined within the hive due to spring rains. Conversely, *Varroa* infestations peaked during the months of August through November, a critical time of year in temperate climates when colonies must rear bees in preparation of winter. Not only does this result in poor overwinter colony survival rates, but without intervention from the beekeeper, the collapse of highly infested colonies has been demonstrated to cause neighboring colonies to experience a surge in mite populations. Peck and Seeley (2019) found that the collapsing hives likely serve as “robber lures” for neighboring hives, thus spreading mites to robber bees which then transport them back to their original hive. For more information on transmission dynamics within and between colonies, see Chapter 27 in this textbook. In addition, mite-infested workers from collapsing colonies that drift into neighboring colonies also likely play a role in *Varroa* spread. An important biosecurity practice, therefore, is to identify and remove collapsing colonies early.

1.5 Honey Bee Viruses

Viral diseases are a major threat to honey bee health and the ability of the *Varroa* mite to vector a multitude of viruses has been a major driver of honey bee decline (Brosi et al. 2018; Traynor et al. 2015). Honey bee viruses can infect all developmental stages of honey bees including the egg, brood, and adults and colonies can be co-infected with multiple viral pathogens simultaneously (Chen et al. 2005; Chen 2006; Shen et al. 2005). For example, Traynor et al. (2015) found that *Varroa* levels were significantly elevated in sampled bees that concurrently tested positive for both acute bee paralysis virus (ABPV) and deformed wing virus (DWV). Both ABPV and DWV increased in viral load linearly with mite levels, indicating that mite presence is directly linked to viral replication for these two viruses (Traynor et al. 2015). These complex host-parasite interactions are a source of increasing concern and intensified research in the beekeeping community. For more information on viral diseases of honey bees, see Chapter 14 in this text.

Viral screens conducted through the National Survey suggested a concerning trend of escalation in the prevalence of several viruses during 2009-2014 with black queen cell virus (BQCV), chronic bee paralysis virus (CBPV), Kashmir bee virus (KBV), and Lake Sinai Virus 2 all increasing in prevalence during this time (Traynor et al. 2015). In addition, CBPV was undetected in 2009 but doubled annually between 2009 and 2014 (Traynor et al. 2015). This increasing trend in the prevalence of numerous viruses may suggest that the honey bee's immune system is compromised resulting in the inability to protect itself against a number of stressors including but not limited to decreasing habitat, increased pressure from pesticides, and poor nutrition (Archer et al. 2014; Bryden et al. 2013; Higes et al. 2009; Pettis et al. 2013; Sanchez-Bayo 2014; Simon-Delso et al. 2014; van der Sluijs et al. 2013), ultimately leading to increased colony mortality (Johnson et al. 2010; Spleen et al. 2013; Steinhauer et al. 2014; vanEngelsdorp et al. 2008, 2012).

1.6 Viral Transmission

According to Chen (2006), transmission processes are a crucial aspect of the dynamics of viral infections and determine the spread and persistence of disease in a population. Viral transmission generally occurs through either horizontal or vertical routes and honey bee viruses utilize both of these strategies (Amiri et al. 2017; Chen et al. 2005; Chen 2006; Shen et al. 2005). Horizontal transmission can be either direct or indirect. Direct horizontal transmission includes airborne, foodborne, or venereal routes whereas indirect horizontal transmission involves an intermediate biological host, such as a mite vector, which acquires the virus and then transmits it from one host to another. This type of transmission occurs among individuals of the same generation. Vertical transmission takes place when viruses are passed from mother to offspring via the egg, either within the egg (transovarian) or on the surface of the egg (transovum). Horizontal transmission typically favors apparent disease expression and infection prevalence often increases in conditions of high host population density and high pathogen replication rates that result in increased opportunity for viruses to spread from organism to organism. Conversely, vertical transmission allows for long-term persistence of the virus within the population and favors a more benign disease process which allows offspring to survive and continue to propagate spread of the virus on to the next generation. Viral infections within a population often reflect a complex balance in evolutionary trade-offs between the two transmission processes. (Chen 2006)

1.7 Knowledge and Management Practices as Drivers of Honey Bee Health

Despite increased knowledge of honey bee disease epidemiology as well as numerous local, regional, and national initiatives to promote pollinator health, a comprehensive understanding of the drivers of poor honey bee health and colony loss remains minimal. Specifically, the impact of beekeeper knowledge and management practices on colony health is poorly understood. Jacques et al. (2016) conducted a descriptive epidemiological study across 17 European countries to identify key risk factors surrounding honey bee colony mortality. Results demonstrated that the winter mortality rate of hobbyist beekeepers with small apiaries and little beekeeping experience was double that of professional beekeepers. In addition, observed disease prevalence, including *Varroa* infestation, was significantly higher for hobbyist beekeepers than professional beekeepers. Overall, the researchers concluded that while climactic conditions and other biological variables were drivers of honey bee health, the main factors in determining the health of honey bee colonies were beekeeper background and management practices. Thus, they recommended a stronger focus on the need for beekeeper training to promote good management practices and enable beekeepers to detect clinical signs of disease earlier and intervene appropriately.

2 Biosecurity

As demonstrated by Jacques et al. (2016), the successful management of honey bee colonies requires knowledge and implementation of good husbandry practices, including a focus on biosecurity. The field of biosecurity as it relates to honey bee veterinary medicine serves as an opportunity for veterinarians to provide biosecurity education and audits to beekeeping clients as part of a comprehensive honey bee health program. To assist veterinarians and beekeepers in conducting such an audit, a *Beekeeping Biosecurity and Best Practices Checklist* is included at the conclusion of this chapter as Appendix 10.A and can also be downloaded as a fillable PDF from the Center for Food Security and Public Health at the following web address: www.cfsph.iastate.edu.

Biosecurity is defined as a series of management practices used to prevent the introduction and spread of pathogenic agents (Center for Food Security and Public Health 2015). Just as with other animal and livestock premises, biosecurity principles can be implemented in apiaries to protect honey bee colony health. Failure to apply good biosecurity techniques can result in the introduction of exotic pathogens or the establishment of endemic pathogens which may spread to surrounding apiaries and could have detrimental effects on the honey bee industry at the regional, national, and even international level. As such, the responsibility of practicing good biosecurity begins at the individual level and is in the best interest of every beekeeper; however, the protective effects are cumulative, widespread, and serve the greater good of the beekeeping and agricultural industries.

2.1 General Management Practices for Biosecurity

2.1.1 Training

All beekeepers and their employees should obtain training on best management practices (BMPs) and should make every effort to remain current on evolving developments in the beekeeping industry. Over the years, a number of organizations have developed resources on BMPs for honey bees. One such resource compiled by the Honey Bee Health Coalition (2019) offers valuable BMPs on several topics including beekeeper safety, honey bee nutrition, hive and apiary set up and maintenance, pesticide exposure, treatment of parasites and diseases, and queen health, breeding, and stock selection. This guide, entitled "Best Management Practices for Hive Health: A Guide for Beekeepers" can be accessed free of charge at the following website: https://honeybeehealthcoalition.org/hivehealthbmps. It is also recommended that beginning beekeepers complete a beekeeping course and join local and state beekeeping associations in their area as this can serve as an excellent networking opportunity and allow beginners to learn from more experienced and knowledgeable beekeepers.

According to OIE and FAO (2009), beekeepers should actively seek and complete relevant training opportunities and keep records of all training completed by them and their employees. As part of this training, beekeepers should be aware of potential exotic and endemic threats to honey bee health in their area, and areas where their hives may be transported, as well as regulations, reporting requirements, and legal obligations for detection of certain pathogens (Plant Health Australia 2016; Vidal-Naquet 2015).

2.1.2 Record Keeping and Traceability

Record keeping is essential for good colony management and allows the beekeeper to better understand and identify the root cause of health or sanitary issues. Records should be kept on the following:

- Number of hives and apiaries (and identification of individual hives),
- Introduction of new stock whether originating through purchased packages or nucleus colonies, splits, or swarms,
- Migratory beekeeping movements, including routes taken and dates,
- Date, origin, and type of feeding supplements administered,
- Date, origin, dose, and use of any natural or medicinal treatments administered,
- Date, origin, and use of any chemicals or cleaning products used on hive equipment, and
- Notes and findings of all hive inspections conducted, including but not limited to normal and abnormal findings, suspected/diagnosed diseases, mortalities, colonies affected, and methods to correct/remove problems. (Vidal-Naquet 2015)

In addition, all colonies and apiaries should be marked with unique identification to allow for traceability through record keeping. Queens should also be marked according to the international color code to allow for traceability (if she leaves with a swarm) and easier identification during hive inspections (Vidal-Naquet 2015). There are five internationally recognized marking colors for queens with the color sequence depending on the year that the queen was born. Because queens rarely live more than five years, the color code starts over again in year six. Marking queens according to the international color code not only allows for them to be more easily identified within a hive but also allows for a consistent method within the beekeeping industry to indicate which year the queen was introduced into the colony. (Piedmont Beekeepers' Association 2017)

2.1.3 Apiary Placement and Signage

The location of the apiary and hives within it will play an important role in colony health. To promote healthy colonies, the beekeeper should:

- Ensure easy, but controlled, access to the apiary,
- Ensure the apiary and surrounding area is well maintained,
- Ensure that hives can be placed in a manner in which they will be protected from inclement weather and other hazards to the extent possible,
- Ensure the presence of diverse, natural food sources,
- Ensure the presence of a good quality water supply,
- Know, if possible, of the farming practices used nearby, including pesticide use, and
- Know, if possible, the presence of nearby colonies and the management practices utilized in those apiaries. (Vidal-Naquet 2015)

Signage is also important and should be well designed and clearly posted. Biosecurity signs providing the apiary owner's name and contact information should be placed at apiary or property entrances to alert people to contact the apiary owner and obtain permission before entering the property. The apiary owner's name and contact information will also be essential in the event of a biosecurity incident (such as an exotic pest detection) or emergency. In the case of migratory colonies, signs should accompany hives to their new location. (Plant Health Australia 2016)

2.1.4 Sourcing

Proper sourcing of stock, equipment, and supplementary feed products is an important part of a good biosecurity program and will play a vital role in the foundational health of the colony. All purchased queens and bees should come from trusted sources and should be pest-free to the extent possible (Plant Health Australia 2016). Thought should also be given to the honey bee strain chosen to ensure it is appropriate for the environment in which it will be placed and the pathogens to which it will potentially be exposed (Vidal-Naquet 2015). Strains vary in a number of characteristics, including but not limited to their temperament, ability to build up honey stores, hygienic behavior, disease resistance, and ability to overwinter. Honey bees in the US and Canada are a genetic blend of several strains/subspecies introduced from Europe and many new hybrids have been introduced in an attempt to optimize the available genetics (Mid-Atlantic Apiculture Research and Extension Consortium 2020). It is important to holistically consider honey bee genetic traits when determining which strain is best for the environment in which the hives will be placed. Just as with purchased stock, wild swarms can serve as a potential hazard as they pose the risk of disease introduction. Recovered swarms should be isolated from the apiary until a thorough inspection can be conducted and any necessary treatments, such as miticides, can be applied (Vidal-Naquet 2015).

Hive equipment should also be purchased from a reputable source and the choice of materials used should be appropriate for the local environment. Hives must remain dry inside and any paints or waxes applied to the materials must be safe and compliant with regulations for food-producing animals (Vidal-Naquet 2015). Borrowed and secondhand equipment should also be cleaned and disinfected thoroughly before use (Plant Health Australia 2016). Equipment must also be maintained appropriately as the hive boxes, frames, and foundations will deteriorate over time, providing conditions favorable for disease and pests.

Frame management is especially important as pathogenic agents and residues of treatments and pesticides can accumulate over time. Dark wax combs should be removed and hive frames should be renewed every two to three years (Vidal-Naquet 2015). To the extent possible, all frames and supers should be associated with one hive and exchange of hive boxes between colonies and apiaries should be minimized. All empty hives should be immediately removed from the apiary, cleaned to remove visible propolis and other debris, disinfected with a mild bleach solution, and rinsed thoroughly before storing. Equipment should be stored without chemical treatment in a well-ventilated area. Hive boxes with frames should be stored in a crisscross pattern to allow for ventilation and opening in the top and bottom of the box to protect against wax moth infestation. (Vidal-Naquet 2015)

Supplementary feed products should be obtained from trusted sources and should be stored and handled appropriately. For more information on honey bee nutrition, see Chapter 25 in this text.

2.2 Colony Management Practices

Animal management is a key part of any livestock biosecurity program and honey bees are no exception. The biology of honey bees and our inability to protect them from the environment and predation presents unique challenges in this arena. All-in/all-out approaches cannot be adapted to colony management as bees are the one species of livestock where the animal, rather than the farmer, controls the food supply of the colony (Vidal-Naquet 2015). As such, there is an even greater reliance on husbandry practices to ensure the health of the colony.

2.2.1 Hive Inspections

Routine hive inspections are of utmost importance and apiarists must manage hives year-round. Overall activity of the bees both outside and within the hive, brood patterns, pollen and honey storage, and signs of disease and pests should be assessed. More details on hive inspections can be found in Chapter 10 of this text. Due to their ubiquitous nature in the US and detrimental impacts on colony health, *Varroa* mite infestations should be monitored and managed appropriately throughout the year as part of an integrated pest management program. This component of beekeeping has become increasingly vital to ensure honey bee health and the success of the beekeeping industry. More information about integrated pest management and *Varroa* control can be found in Chapter 18of this text.

During hive inspections, any abnormal findings or signs of disease should be recorded and carefully monitored. All regulations and legal obligations to report disease suspicions should be followed as necessary. In some cases, diseased colonies that have the potential to recover may be worth saving. If feasible and allowable by law, these colonies should be isolated from the apiary as this will limit the risk of disease transmission to other healthy colonies within the apiary. Weak hives, or those that may pose a danger to other colonies within the apiary, should be humanely euthanized. (Vidal-Naquet 2015) For more information on how to appropriately euthanize a colony, see Chapter 22.

2.2.2 Sanitation and Hygiene

Practicing good sanitation and hygiene is a key component of any biosecurity program. All small tools and clothing (e.g., gloves, beekeeping suits, hive tools, brushes) should be disinfected with a mild bleach solution or alcohol between inspections of different apiaries and after inspection of any colony that appears to be diseased (Honey Bee Health Coalition 2019, Vidal-Naquet 2015). For the veterinarian, disposable gloves are a preferred option. In addition, workers, visitors, and vehicles can be contaminated and serve as routes of pathogen introduction and transmission to other hives and should be cleaned before entering and leaving the apiary (Plant Health Australia 2016).

2.2.3 Special Considerations for Migratory Colonies

The movement of hives for pollination services increases the risk of disease and pest spread to other regions, so special precautions should be taken. To the extent possible, movements should be minimized as constant transportation results in increased stress for the colony and makes them more susceptible to disease or infestation. For risk reduction purposes, the following management practices should be implemented whenever hives are transported:

- Before moving any hives or products, contact the destination State Department of Agriculture/Apiary Inspector to determine any requirements for health certification as these vary by state/territory (a list of US Honey Bee Laws by state is available at https://apiaryinspectors.org/state-laws/; however, you should always verify their accuracy with the Department of Agriculture/Apiary Inspector prior to transport),
- Assess any potential disease threat that might be posed by poorly managed hives near the new location,
- To minimize stress on the colony, hives should be moved at night or in the early morning when bees are inside,
- Transported colonies should be fed a carbohydrate supplement prior to shipment to prepare them for the journey,
- Be knowledgeable about all endemic and exotic pathogens, as well as disease reporting regulations, in the region to which the hives are being moved,

- Ensure that hives and equipment are covered and secured to prevent robbing by other bees,
- Keep accurate records of all hive movements for traceability purposes, and
- Follow all transportation regulations. (Plant Health Australia 2016; Vidal-Naquet 2015)

2.3 Summary

Beekeepers and honey bee veterinarians have an important role to play in ensuring the health of bees and protecting the honey bee industry. As described by Plant Health Australia in their *Biosecurity Manual for Beekeepers* (2016), there are six easy steps that beekeepers and veterinarians can take to reduce threats from exotic and endemic pathogens:

1. Be aware of biosecurity threats in your region including all exotic and endemic pathogens.
2. Use healthy honey bee stock and clean equipment from trusted sources.
3. Practice good sanitation and hygiene and ensure that all workers, visitors, vehicles and equipment are clean before entering and leaving the apiary.
4. Monitor hives carefully and report any unusual findings. Keep written and photographic records of all abnormal observations as constant vigilance is necessary for early detection of disease.
5. Be knowledgeable of and abide by all laws and reporting regulations in your region.
6. If you suspect an exotic pest or pathogen or other reportable disease, contact your State Apiary Inspector or State Department of Agriculture immediately.

2.4 The Role of the Veterinarian in Biosecurity

As noted above, veterinarians working in honey bee medicine can provide valuable services to clients related to biosecurity and management for disease control. Using the biosecurity threats and principles detailed herein, veterinarians should consider developing biosecurity and management checklists with which they could conduct audits of their clients' apiaries (see Appendix 10.A as an example). The goal of the audits would be to provide clients with effective strategies to prevent the introduction of exotic and endemic pathogens and to mitigate the impact of endemic pathogens that enter the hive. This approach would be particularly helpful to inexperienced hobbyist and sideline beekeepers who would likely benefit most from professional assistance with their beekeeping education and management practices.

Appendix 10.A: Beekeeping Biosecurity & Best Practices Checklist

Audit Conducted by____ Date______________

Apiary Owner & Contact Information____

____

Apiary Address/GPS Coordinates____

Recommended Best Practices	In Place	In Progress	Not In Place	Comments
Training				
Complete training/maintain current knowledge of beekeeping through CE (beekeeper and employees)				
Possess knowledge of and be able to recognize all exotic and endemic threats to honey bee health in all hive locations				
Know current regulations and disease reporting requirements for all hive locations				
Record Keeping/Traceability				
Document completion of all training programs for beekeeper and employees				
Maintain current contact information for State Apiary Inspector/State Department of Agriculture for all hive locations				
Record number of apiaries and number of hives within each apiary				
Record any introduction of new stock, including source				
Record migratory hive movements, including routes taken and dates				
Record date, origin, and type of feeding supplements administered				
Record date, origin, dose, and use of any natural or medicinal treatments administered				
Record date, origin, and use of any chemicals or cleaning products used on hive equipment				
Record findings of all hive inspections conducted throughout the season including normal/abnormal findings, suspected/diagnosed diseases, mortalities, colonies affected				
Mark all colonies and apiaries with unique identification				
Mark all queens according to international color code				

Apiary Placement				
Ensure easy, yet controlled, access to apiary				
Ensure apiary/surrounding area is well maintained				
Ensure hives are protected from inclement weather/other hazards to the extent possible				
Ensure presence of diverse, natural food sources				
Ensure presence of good quality water supply				
Possess knowledge of nearby farming practices, including pesticide use				
Possess knowledge of nearby colonies and management practices utilized				
Sourcing				
Purchase queens/bees from trusted sources and ensure they are pest-free to the extent possible				
Choose appropriate honey bee strain for regional environment of hive location/potential pathogen exposures				
Isolate recovered wild swarms from apiary until thoroughly inspected/miticides applied (if needed)				
Purchase hive equipment from reputable source made with appropriate materials				
Clean and disinfect any borrowed/secondhand equipment before use				
Maintain hive boxes/frames/foundations over time including removal of dark wax combs and replacement of hive frames every 3 years				
Minimize exchange of frames and supers between colonies and apiaries to the extent possible				
Remove all empty hives from apiary immediately				
Store equipment in well-ventilated/chemical free area and store hive boxes in crisscross pattern				
Obtain supplementary feed products from trusted source and store/handle appropriately				
Ensure supplemental feed is appropriate for needs of colony and time of year (winter/early spring = candy; late spring/fall = syrup; honey sourced only from colony/apiary in which hive is located)				
Hive Inspections				
Conduct routine hive inspections				
Observe and document the following during inspection: queen status, activity of bees outside and within hive, brood patterns, pollen/honey storage, signs of disease/pests				
Implement and document presence of an integrated pest management program				

Isolate any diseased colonies from apiary that can be saved (as allowable by law)				
Humanely euthanize any weak hives or those that pose danger to other colonies				
Sanitation/Hygiene				
Disinfect all small tools/clothing between inspection of different apiaries and after inspection of any apparently diseased colony				
Ensure that all workers/visitors/vehicles are clean before entering and leaving the apiary				
Display signage at apiary/property entrances with apiary owner's name/contact information and a request to obtain permission before entering				
Migratory Colonies				
Minimize movement of hives to the extent possible				
Contact destination State Department of Agriculture/Apiary Inspector prior to any hive movement to determine health certification requirements				
Move hives only at night/early morning				
Feed colonies carbohydrate supplement prior to moving				
Possess knowledge of all established/exotic pathogens and disease reporting regulations in region to which hives are being moved				
Cover and secure hives/equipment prior to moving				
Assess any potential disease threat due to poorly managed hives near new location				
Keep accurate records of all hive movements				
Follow all transportation regulations				

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