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Bees in the Neighborhood: Best Practices for Urban Beekeepers

VIRGINIA Lj. BOLSHAKOVA, Director, Out-of-School Programs, Indiana GEAR UP; **ELINA L. NIÑO**, University of California Cooperative Extension Assistant Specialist, University of California, Davis

Pollination is an essential ecosystem service, and bees are critical to the rich diversity of fruits, vegetables, and nuts we eat. Close to 75% of all flowering plants on Earth rely to some degree on pollinators in order to set seed or fruit. Pollinators are required for producing 15 to 30% of the human food supply, and farmers throughout the world rely on managed honey bees to provide these services (Greenleaf and Kremen 2006). The value of the European honey bee, *Apis mellifera* L., to pollination services is estimated at $217 billion globally and $20 billion in the United States annually (Frankie et al. 2014). In California alone, about one-third of agricultural revenue comes from pollinator-dependent crops.

Declines in pollinator populations could have serious economic repercussions throughout the United States and the world, including rising food costs and potential crop failures (see Potts et al. 2016). Specifically, in the United States, the number of managed honey bee colonies has decreased by 50% since 1945 (vanEngelsdorp and Meixner 2010). This decline also highlights the danger of an overreliance on a single species, such as the European honey bee, for pollination services (see Garibaldi et al. 2013). Much research has been spearheaded in recent years to understand the contributions of other pollinators, such as native bees, to our food systems. Even the federal government published the *Pollinator Partnership Action Plan,* which outlines a plan to support struggling pollinator populations. The federal efforts aim to decrease honey bee colony losses to below 15% annually within 10 years and to restore seven million acres of pollinator habitat over 5 years across the United States through public-private partnerships (The White House, May, 2015; The White House, June 2016).

Ecosystem services such as crop pollination are important for ensuring food security for the growing world population (e.g., Daily 1997); understanding how to manage such resources is fundamental for supporting these efforts. In large-scale agricultural production, studies have documented the increased value in pollination services when native, nonmanaged bee populations are in close proximity (see Brittain et al. 2013; Frankie et al. 2002; Kim 2004; Kremen et al. 2004). However, currently, large-scale agriculture in the United States still largely depends on honey bees for crop pollination.

Honey bees obtain significant pollen and nectar of diverse nutritional value from many native plant species found in natural habitats (Kremen et al. 2002). Developed environments sometimes provide fewer resources than natural habitats and present unique challenges that should be addressed. Urbanization causes an irreversible change to the environment, leading to fragmented habitats in urban and suburban areas. Not enough is known about urbanization effects on the composition of insect communities, including beneficial insects such as bees, wasps, and other beneficial arthropods that are vital to sustaining healthy ecosystems. However, encouraging results from the Urban California Native Bee Survey (Frankie et al. 2014) demonstrate that providing floral square footage of pollinator-supportive plants throughout the foraging seasons can help sustain diverse bee populations across urban landscapes. The media coverage of the peril of pollinators has led to the general public wanting to help bees in particular. The public can have a greatpositive impact on pollinator health by providing plentiful nectar and pollen resources by planting a diversity of pollinator-supportive plants, rather than engaging in beekeeping, especially since we still do not fully understand how much pollinator-supportive landscape is needed to provide optimal resources for local bee populations.

Public awareness about pollinator importance and the growing interest in urban beekeeping (usually considered a subcategory of backyard beekeeping) has led many local and municipal governments across California to revisit ordinances to acknowledge and potentially facilitate this developing resurgence in the trade and hobby. For example, in the last 10-12 years, membership in the Beekeepers' Guild of San Mateo County grew nearly tenfold, from 40 to a current level of about 400 members (N. Irvine, San Mateo Beekeeper Guild, pers. comm.). This has presented a unique need for developing guidelines for responsible beekeeping in urban and suburban areas with particular emphasis on neighbor relations and safety.

Further, urban beekeepers may play an important role in supporting honey bee health through early detection of pests and pathogens and by preventing their spread by adhering to proper best management practices. Urban and suburban beekeepers could also provide a link between the general public and commercial beekeepers by promoting the importance of pollinators in agricultural ecosystems and educating the public on how to help support pollinators, such as by planting pollinator-supportive plants. It is therefore essential that guidelines for best management practices be benchmarked to ensure good stewardship by beekeepers in urban and suburban areas.

Compliance with State and Local Authority

A beekeeper should comply with all applicable state, county, and city regulations. State laws, regulations, and more can be found at the California Department of Food and Agriculture's (CDFA) Pollinator Protection website, https://www.cdfa.ca.gov/plant/pollinators/index.html. Additional helpful information can be found at the California Department of Pesticide Regulations (CDPR) Pollinator Protection website, http://www.cdpr.ca.gov/docs/enforce/pollinators/.

For laws specific to your county, contact your county Agricultural Commissioner's office (see the CDFA website, https://www.cdfa.ca.gov/exec/county/countymap/) or your local University of California Cooperative Extension office (http://ucanr.edu/County_Offices/).

For city-specific laws, please check your city's ordinances or contact your city's offices.

Figure 1. The "Do You See a Honey Bee?" poster shows a diversity of color forms of *Apis mellifera. Source:* A. Jones

Basic Honey Bee Biology

The European honey bee is not native to the western hemisphere; their value for producing honey and wax led to their introduction by early European colonists (vanEngelsdorp and Meixner 2010). Honey bee workers are about ½ to ⅝ inch long, with an orange-to-yellowish-brown to almost black body color and black stripes on the abdomen (fig. 1). The legs, antennae, and eyes are black; the thorax, abdomen, and legs are densely covered with hairs. Pollen is often seen carried in a ball on their hind legs attached to special structures called pollen baskets (corbicula). Honey bees build their nests from wax produced by their wax glands, and they locate nests inside hollow trees and other types of protected cavities (e.g., walls). The males, or drones, are significantly larger than honey bee workers and have notably larger eyes that touch together at the top of the head. Queens mated with drones are typically the largest individuals in the hive, being both longer and wider than worker bees. The queen bee's larger abdomen is noticeably more triangular and pointed than the abdomens of either workers or drones.

Queens mate only once in their lifetime with an average of 12 to 14 drones during a mating flight over a period of 1 or 2 days (Tarpy and Nielsen 2004; Tarpy et al. 2013). The queen lays eggs continuously for the rest of her life and never leaves the colony again unless there is a swarming or absconding event (Winston 1987). Queens are the only reproductive females that can lay fertilized (female) eggs. Eggs are laid in comb cells and, after hatching, the grublike larvae are fed by workers. Female larvae can become either workers or queens, depending on the needs of the colony. This outcome is regulated by worker-provisioned food: royal jelly is continuously fed to queen-destined larvae, and worker jelly is fed to worker-destined larvae (Kamakura 2011; Mao et al. 2015). In the absence of a queen, workers can start laying unfertilized (male, drone) eggs. The queen releases pheromones that affect a variety of behaviors and physiology of the workers in the colony (reviewed in Grozinger 2015). Interactions between the queen and the workers are complex and well worth investigating further.

General Maintenance and Considerations for Hive Management

Hives

Colonies should be kept in hives with removable frames, such as Langstroth, top-bar, or Warre hives. The advantage of these hives is that honey bees build the comb into frames that can be moved and inspected with ease, allowing a beekeeper to better manage the colony by, for example, taking preventative measures against pests and diseases. It can also help the beekeeper determine whether the colony is low on food stores, which may suggest the need for additional feeding. For example, if larvae are floating on a large pool of brood food, this usually indicates sufficient food stores; if larvae appear dry and have very little brood food, this usually indicates insufficient food (particularly protein).

Hive Placement

Keep your hives on your own property; if the hives are kept elsewhere, you should have written permission from the property owner allowing you to keep bees in that location. When placed on someone else's property, a sign giving contact information for the beekeeper must be posted according to California Food and Agriculture Code §§ 29040–29056 (see https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=FAC&division=13.&title=&part=&chapter=1.&article=4). Placement of hives is an important consideration for responsible beekeeping, especially in urban or suburban areas, where people live in very close proximity. To avoid unnecessary colony disturbance, hives should be placed in a quiet area of the lot. Alternatively, hives can be placed 8 feet above the ground (e.g., on rooftops). Hives are best placed as far away from neighboring properties as possible, as well as away from roads, sidewalks, trails, and other pedestrian rights-of-way. Hive entrances should face in a direction so that bees leaving the hive fly across your property. If necessary, you may redirect flight paths up and away from neighboring properties by using barriers such as hedges, shrubs, fabric, or fencing elevated in front of the hive entrance(fig. 2).

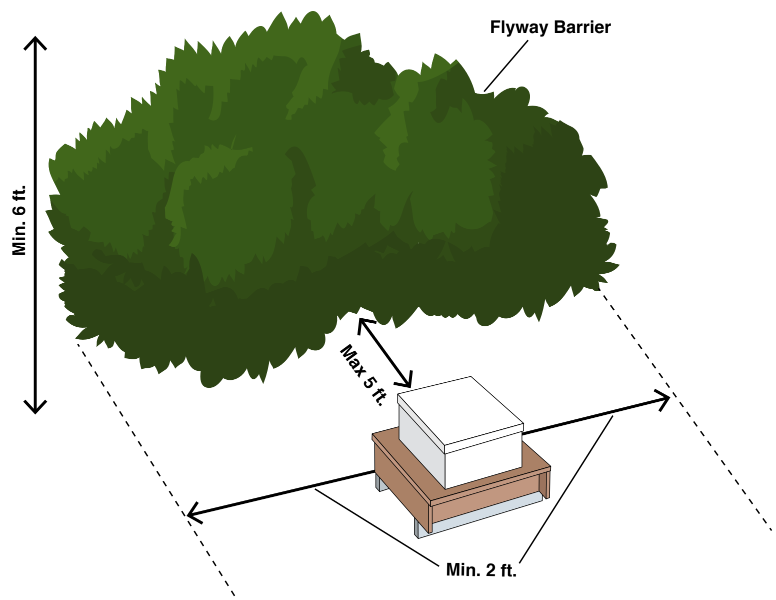

Figure 2. An example of a flyway barrier in front of a colony, which forces the foragers to fly up, minimizing their access to neighboring yards.

Hive placement and hive density is situational; lot size, proximity to human and other animal activity, water and food resources, and neighbor tolerance are just some factors to be considered. One of the primary limitations to keeping bees is the real or perceived interaction between bees and people who live in or use the surrounding area (see the sections "Bee Allergies" and "Bee Phobia," below). To minimize this issue, limit the number of hives you keep to avoid becoming a nuisance and a possible hazard to your neighbors. Notifying neighbors that honey bee colonies will be placed nearby might be advisable and could work toward avoiding future misunderstandings. Cities and counties often specify allowable hive numbers in their ordinances (e.g., San Diego County. see http://www.sandiegocounty.gov/content/dam/sdc/awm/docs/condensed%20Bee%20Ordinance%209-15-15.pdf and Tehama county http://co.tehama.ca.us/images/stories/agriculture/ApiaryOrdinance.pdf), so before obtaining colonies, consult with your local authorities. While the number of hives can be temporarily increased in certain circumstances (e.g., during honey extraction, queen rearing/breeding, etc.), the number of hives should be restored to lower numbers as soon as the activity is completed. Getting consent from all adjacent property owners and residents to increase hive numbers to an explicitly stated hive density could provide a guide to accommodating higher-density apiaries while keeping in mind that these numbers might have to be adjusted if bees prove to be a nuisance.

Provision of Water and Food

Ideally, hives should be placed in an area with a variety of floral resources that bloom throughout the foraging season and an adequate fresh water supply throughout the growing season. The amount of forage needed depends on many variables. A backyard garden crop may flourish due to a resident honey bee colony. Such a garden, however, is only a minimal share of the nectar and pollen required for supporting a colony. Further, not all nectar and pollen resources are equal because some blooming plant species, such as the California buckeye (*Aesculus california*), have a toxic effect on honey bees (Mussen et al. 1987; Detzel and Wink 1993). To minimize toxic exposure to hives, move bees away from unsuitable forage or place pollen traps at the hive entrance. If pollen traps are employed, supplemental feeding might be necessary.

A report from London, UK, highlighted the need for adequate foraging areas to support urban pollinator needs (Alton and Ratnieks 2013). As a result, and instead of increasing the number of urban honey bee hives, London residents are planting species that support pollinators throughout the city. This project may increase honey yields for individual bee colonies and also to educate the public on sound beekeeping practices (e.g., limit the number of colonies in a given area to allow access to adequate forage).

Ensure that a clean water source is available for your bees *before* placing the hives. A water source should be available year round, particularly during severe drought. In very hot weather, bees use a large amount of water to maintain temperature and humidity within the hive. A summer colony requires at least 1 quart of water per day and even more when temperatures are extremely high (Flottum 2014). Bees prefer to obtain water at a sunny place with surface moisture, for example, wet sand or gravel, the edge of a birdbath, a soaker hose, etc. Considering the possibility for mosquito-borne diseases, it is crucial to minimize water sources that may be suitable for mosquito reproduction; providing a very shallow water source (e.g., wet sand, soaker hose) is preferable. Establish water sources before placing the hives, as the bees will acclimate to their presence and be less likely to visit swimming pools, landscape water features, or animal water bowls that are often the cause of conflict with neighbors. Verify that bees are visiting appropriate water sources. If they are not, change the type or location of water sources and make other adjustments as needed.

If bees become a nuisance for the neighbors it might be necessary to temporarily relocate hives and return them after a period of at least 3 weeks (MAAREC 2016). Make sure to provide a new water source at both the old and new locations. Optimally, the bees should be moved at least 4 to 5 miles from the original location. Inquire with a local honey bee association for assistance because fellow beekeepers may provide temporary space. An up-to-date list of California beekeeper clubs and associations can be found at the U.C. Davis E.L. Niño Bee Lab website, http://elninobeelab.ucdavis.edu/CAbeeAssociations.html.

Nectar, pollen, and water are essential to the honey bee diet. Bees obtain carbohydrates for energy from nectar and honey, while protein, fats, vitamins, and minerals are supplied mostly from pollen. No single pollen source completely fulfills their nutritional needs. A diverse pollen diet helps to improve honey bees' immune and detoxification responses, which aid in dealing with pests, pathogens, and even pesticides (e. g., Alaux et al. 2010; Schmehl et al. 2014). Honey bees store honey and pollen in their hive to provide food when nectar or pollen is in short supply or unavailable, such as during drought or winter. During these times, it is important to monitor the amount of honey in the hive as well as the pollen stores available because a colony can starve if resources are depleted.

When colony inspections reveal little to no pollen in the combs or the weather may prohibit pollen and nectar foraging for more than a few days provide a nectar and pollen substitute to supplement nutritional needs of the colony. Feeding a pollen substitute such as brewer's yeast or other commercially available supplements (e.g., Ultra Bee, MegaBee, Feedbee, Bee-Pro, etc.) is especially important in late summer, fall, and throughout the winter to build populations for overwintering survival and early spring pollination. A potential source of nectar supplement is sugar syrup, dry sugar, sugar candy, or other commercially available supplements (e.g., Pro-Sweet, high-fructose corn syrup, etc.). Feeding colonies directly in the hive is preferable, as open food sources can attract bees from nearby managed and feral colonies. Open feeding also facilitates conflict between bees and opportunistic robbers that can agitate a colony and increase defensive behavior, and food source sharing can increase parasite and pathogen transmission (Fries and Camazine 2001). Supplementing essential nutritional resources decreases robbing, minimizes disease spread, and helps curb bee defensiveness, which is good for the bees, good for beekeepers, and good for your neighbors.

Honey bees also collect plant resins and minimally process them into propolis or "bee glue." Bees use propolis to line the inside of their nest, plug holes, and in extreme cases, propolize (seal up) carcasses of unwanted hive intruders (e.g., mice) to minimize the spread of infection. While it might be frustrating to work with a heavily propolized hive, it might be worth the trouble. Research shows that propolis has antimicrobial properties and is beneficial to honey bee health (Simone-Finstrom and Spivak 2010).

Colony Inspection and Hive Manipulation

Take into account that weather conditions influence bee behavior and should plan to work with bees when conditions are favorable (sunny days with a temperature from 55° to 90°F, no rain, and minimal wind). Make sure that neighbors are not working or relaxing outdoors when you open hives and should try to perform hive manipulations as quickly as possible, with minimum disturbance to the bees. Extended hive manipulations, particularly removing honey, should be carefully planned to accommodate neighbors' activities. Ensure that no bee comb or other material that might encourage robbing is left on the ground at the apiary site. All such materials should promptly be disposed of in sealed containers or immediately placed in a building or other bee-proof enclosure. This minimizes bee robbing behavior and mitigates a potentially hazardous situation. Use smoke when working bees and should smoke hive entrances before mowing or trimming vegetation in the hive area. Minimizing vibrations from machinery used around hives is crucial to avoid agitating the bees. Clippings and exhaust should be directed away from hive entrances.

Good stewardship and maintenance of colonies includes regular inspection to gauge overall colony health and resource availability and to provide a general presence in case neighbors may have questions. Inspecting hives once every couple of weeks on average during the most active foraging period (10 A.M. to 3 P.M.) should provide the beekeeper with developing knowledge of the colony status and any required adjustments, treatments, or equipment maintenance. The frequency of colony inspection depends on the season. For example, during the winter (or when temperatures are below 55°F), colonies should be examined minimally or not at all. Routine colony inspections become more critical in the spring around times of great brood expansion (which may lead to swarming) and later in the season when food resources dwindle (which may lead to starvation, defensiveness, or disease transmission). The exact timing of these events depends on the area of the state where you are keeping bees; it is advisable to join a local beekeeping club and learn from more experienced local beekeepers. To find your local bee club in California, see the U.C. Davis E.L. Niño Bee Lab website, http://elninobeelab.ucdavis.edu/CAbeeAssociations.html.

To perform colony inspection, prepare all the necessary equipment and tools before heading out to the hives. Always wear personal protective equipment (PPE) such as a bee jacket, suit, or a veil that protects the head and neck area. To minimize the risk of bee stings, some beekeepers chose to wear gloves, but be aware that this can significantly affect dexterity and in some cases can cause greater bee agitation. Even if you have never had an allergic reaction to bee stings, you can become allergic to bee venom unexpectedly, so it is best to minimize the potential risk.

Approach bee hives from the side while smoking the entrance lightly (3 or 4 puffs). After about 15 seconds, use your hive tool to remove the top cover and puff some smoke over the top frames. Never approach or stand in front of the hive; blocking the flight path may agitate the bees. Smokers can be fueled with a variety of materials, including fine animal bedding (wood chips), pine needles, cotton, burlap, etc. The most practical way to start the colony inspection is to loosen the propolis between the frames by using a hive tool and start with one of the outermost frames. Take the frame out slowly with both hands and inspect it carefully while keeping the frame above the open hive. This minimizes the risk of losing the queen, because if she falls from the frame she will likely fall back into the hive instead of on the ground. Normally, the first frame will have nectar and honey stores on it. While the queen is rarely on this frame it is prudent to always check for the queen before proceeding with the inspection. If the queen happens to be on the first frame, remove the next frame and place the first one back in the hive. If the queen is not on the first frame, you can place it on the ground vertically and lean it against the hive. In fact, pay close attention to locating the queen and ensuring that she is not lost or damaged during the inspection. Never place the frame where the comb and the bees on it can be disturbed.

Examine the remaining frames in a similar manner, except that you should place subsequent frames back in the hive immediately upon inspection and in the order in which they were removed. It is especially important to place any brood frames back in the brood chamber in the middle of the colony. Once the inspection is completed, place the first frame in the outermost position in the hive box from which it was taken. Push frames close together and place the top back in its place. When placing the top back on the hive, disperse any bees clustering on the edges of the box with the hive tool or smoke to minimize crushing them.

During the inspection, check

- the queen and eggs
- the size of the colony population and the brood pattern (e.g., brood frames should have few empty cells)
- the amount of stored food (sufficient pollen and honey)
- whether the larvae are well fed
- the presence of pathogens or pests:
  - Varroa mites, which may be seen on adult bees or developing larvae
  - viruses such as deformed wing virus (DWV), characterized in workers by deformed, shriveled wings
  - bacterial pathogens such as American foulbrood (AFB), characterized by sunken and punctured brood cappings and an unpleasant smell
- equipment that should be replaced
- any other signs not characteristic of a normal healthy colony

If you discover signs of pests, parasites or diseases you should act immediately to rectify the issue. For help, please contact your local University of California Cooperative Extension office, agricultural commissioner's office, local bee club, or the U.C. Davis E. L. Niño Bee Lab. A great varroa mite management resource is the Honey Bee Health Coalition's website "Tools for Varroa Mite Management," honeybeehealthcoalition.org/varroa/.

Queens

The queen is arguably the most important individual in the colony because she lays all of the fertilized (female, worker) eggs, increasing the colony population. During the hive inspection, take note of queen's presence or absence and whether she is the original marked queen. Maintaining a marked queen is useful for quickly locating the queen and referencing her age (see table 1). Marking a queen allows you to determine whether the colony has gone through requeening. This is particularly important if you are trying to maintain a specific bee stock or prevent Africanization of the colony. However, it is not always possible to find the queen, as they tend to move from frame to frame, so you should note the presence of fresh eggs (eggs still standing up have been laid within the past 48 to 72 hours).

Table 1. International queen marking color code

Color	Year ending In
white (or gray)	1 or 6
yellow	2 or 7
red	3 or 8
green	4 or 9
blue	5 or 0

In any instance in which a colony exhibits unusually aggressive defensive behavior, such as stinging or attempting to sting without provocation, or exhibits an unusual disposition toward swarming, it is strongly recommended that you promptly requeen the colony with a queen of known European stock. This is particularly important for ensuring your safety and the safety of your neighbors. Please note that it is not always possible to requeen the colony, as the workers may not accept the new queen. Likewise, it might be difficult to acquire a queen due to low supplies or improper season. Inquire with your local bee association to locate available queens. Remove the old queen at least 24 hours before requeening. Introduce the new queen in a queen cage without attendants and place her between the two brood frames toward the top of the frame (fig. 3). To improve acceptance of the queen, spray the queen cage and the bees in the proximity of the queen cage with 50% sugar water solution. Check in 2 or 3 days to see whether the queen has been released or perhaps not accepted by the workers. If a queen cannot be located and the colony is not overly defensive, the queenless colony can be combined with a colony that has a queen. To combine colonies, place a single perforated sheet of paper (e.g., newspaper) between the two colony boxes (fig. 4) to provide a barrier so the workers do not attack each other and allow them to slowly get accustomed to the smell of the new colony as they chew through the paper to remove it. If an excessively defensive colony cannot be requeened, move it out of an inhabited area or abate (destroy) it.

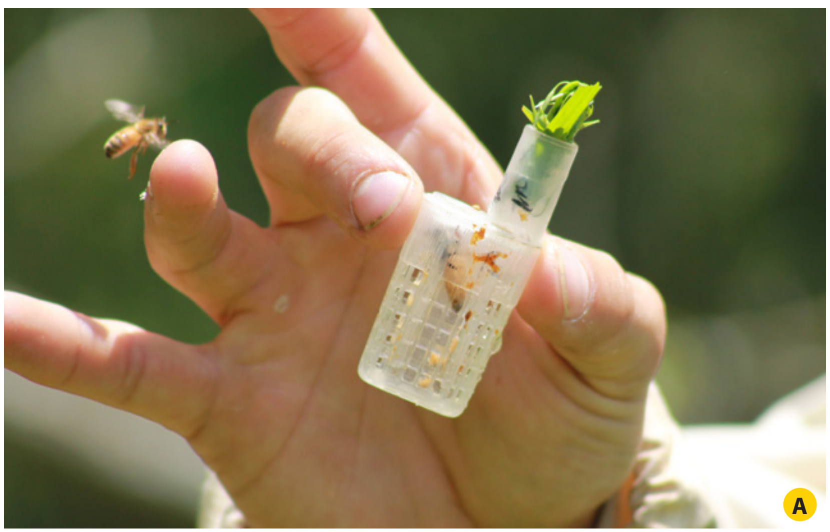

Figure 3. An easy approach to installing a queen is to cage her in a plastic queen cage and cap the cage with grass. Spray the cage with the queen in it with 50% sugar solution in water. Push the queen cage gently into the wax on top of a frame with emerging worker bees and place the frame back into colony next to another frame with emerging workers. *Photos:* Bernardo Niño.

Figure 4. Colonies can be fairly easily combined by placing a sheet of paper (e.g., newspaper, butcher paper, etc.) larger than the dimensions of a hive box on top of the bottom brood box of one of the hives. The paper should be scored with a sharp object such as a hive tool; the hive box from the second colony can then be placed on the newspaper. This allows for gradual mixing of the workers minimizing unnecessary aggression between workers and the aggression of "foreign" workers towards the queen. *Photos:* Bernardo Niño.

Recordkeeping

Declines in pollinator health have left the general public and scientists with many unanswered questions. Without accurate recordkeeping over time, valuable information will be lost and human understanding of bee population biology that informs beekeeping best management practices will be limited. People who are dedicated to tracking accurate information about their honey bee populations can be helpful in building the scientific base for understanding the contemporary challenges of honey bee management. For example, Beetight (https://www.beetight.com/) and Hive Tracks (https://hivetracks.com/) are software products that provide beekeepers with web-based and mobile applications for recordkeeping and data management, making these tasks a bit more manageable. For each hive, it is advisable to record the following information:

- queen's race, name of breeder, color mark or number, and introduction date
- supersedure and/or swarming dates
- records of brood frame marking for the purpose of removal and transition
- dates and types of supplemental feeding
- dates of equipment introduction, such as new frames and foundation (can be written on frames)
- dates (and if possible densities) of pest and pathogen presence, e.g., *Nosema* spp., varroa mite, chalkbrood, AFB (please note that, under California law, colonies with AFB must be abated), European foulbrood, wax moth, etc.)
- pest treatment types and management methods
- inspection dates and notes on inspector's key observations
- dates of honey extraction
- hive location and movement dates

Keeping good hive records contributes greatly to your success as a beekeeper.

Preventing Swarming

Swarming is a natural process of honey bee colony reproduction that occurs chiefly from spring to early summer. To prevent or minimize swarming, take reasonable precautionary measures. For example, brood chamber manipulation (removing frames of brood to slow down the population growth) or adding extra supers with empty frames can reduce the swarming impulse by providing the colony with extra space to grow. Destroying queen cells can also help prevent colonies from swarming. Colony splitting provides more space, as the colony is basically divided in half and the new empty frames are then added into new "daughter" colonies to allow for growth. New colonies will require either a new queen or queen cell, or you can simply let the colony rear a new queen by ensuring that there are sufficient eggs or young larvae. When splitting, be aware of the numbers of colonies that can be supported at the location and move extra colonies to another location if necessary. While swarms rarely pose a threat, neighbors may be alarmed by the sight; thus, collect swarms as soon as possible. If you cannot collect the swarm yourself, contact your local beekeeping association, as they usually have a list of volunteers willing to remove and collect a swarm (e.g., http://www.californiastatebeekeepers.com/links-affiliated-clubs.html or http://elninobeelab.ucdavis.edu/CAbeeAssociations.html). Alternatively, county agricultural commissioners and local University of California Cooperative Extension offices may also provide a list of contacts. Once retrieved, requeening the colony with known gentle, European stock is advised, particularly in areas known to have established Africanized honey bee populations, such as San Diego County (Kono and Kohn 2015; see also http://www.sandiegocounty.gov/awm/bees.html).

Supporting Honey Bee Colony Health by Using an Integrated Pest Management (IPM) Approach

Knowledge is power, and familiarity with what is happening in a hive provides you with a better working understanding of honey bee biology and their interaction with various pests and pathogens. Regular hive inspection is recommended, but overinspection can disrupt normal colony functions. Regular inspections and continued education allow beekeepers to monitor hives for colony stressors and recognize the symptoms of common maladies. Common problems in California apiaries include

- parasites such as varroa mites (*Varroa destructor*)and *Nosema* spp.
- viruses: common viruses include deformed wing virus (DWV), black queen cell virus (BQCV), acute bee paralysis virus (ABPV), chronic bee paralysis virus (CBPV), Israeli acute paralysis virus (IAPV), and sack brood virus (SBV)
- bacterial pathogens, such as causative agents of AFB and EFB
- poor nutrition
- potential exposure to pesticides.

For additional information, see the eExtension website, http://www.extension.org/bee_health). *Prevention rather than intervention* is key. Having a preventive plan and a treatment-response plan will help minimize the impact on overall honey bee colony health. Managing colony health also minimizes the spread of pathogens and parasites to neighboring colonies. Ensuring proper nutrition can go a long way in minimizing negative impacts of pests, pathogens, and pesticide exposure (Alaux et al. 2010; DeGrandi Hoffman et al. 2010; Di Pasqual et al. 2013; Schmehl et al. 2015).

Integrated pest management (IPM) is a method of dealing with pests, parasites, and pathogens that differs from sole reliance on chemical treatment (see table 2 for a list of products for use in hive management). IPM is based on the foundation that long-term pest control cannot be achieved by trying to chemically eradicate pests or parasites; rather, successful pest control requires an ecosystem-based strategy for long-term prevention of pests through a suite of techniques such as habitat manipulation, cultural practices, and use of biological control agents (UC IPM 2016). IPM is a decision-making process based on understanding host and pest biology and host–pest interactions. It involves using tactics such as genetic and cultural methods, mechanical and physical methods, biological control, chemical treatments (fig. 5), and timing treatments to critical stages in the life cycles of the target organisms.

Table 2. Pesticides used for management of various pests in honey bee colonies. Note that some pesticides listed are not registered for use in California.

Pesticide	**Active ingredient**	**EPA registration no.**	**CDPR registration no.**	**California signal word(s)**	**Pest controlled**	**Quick reference application information***
Apiguard	thymol 25%	79671-1	79671-1-AA	**Danger**	varroa mite (also aids in control of tracheal mite)	Application depends on the method of administration, but a 1/4" spacer is usually needed to apply. Recommended application is in the fall and when temperatures are 60° to 105°F. If infestation is severe, it can be used in the spring. Cannot be used when honey supers are on.
Apistan	tau-fluvalinate 10.25%	2724-406	2724-406-ZA	**Caution**	varroa mite	1 strip per 5 frames of bees. Works by contact. Place in brood chamber area. Length of treatment is minimum 42 days and maximum 56 days. Generally, spring and fall and when temperatures are above 50°F. Cannot be used when honey supers are on.
Apivar	amitraz 3.3%	87243-1	87243-1-AA	**Warning**	varroa mite	1 strip per 5 frames of bees. Works by contact. Place in brood chamber and areas of high bee activity. Length of treatment is minimum 42 days and maximum 56 days. Can be used year-round but recommended in spring and fall. Cannot be used when honey supers are on.
API Life Var	thymol 74.09% eucalyptus oil 16.00% L-menthol 3.73%	73291-1	**Not registered in CA**	**Warning**	varroa mite	Cut 1 pack in half. Each half pack will treat one colony. Each half pack will contain two pieces, break the two pieces in half and place the 4 pieces around the edge of the brood nest, not directly above. Total length of treatment is maximum 32 days and can be treated up to two times per year. Temperatures must be 64° to 95°F. Cannot be used when honey supers are on.
Avachem<<AU: I moved this up in alpha order--OK?>>	sucrose octanoate esters 40%	70950-2	**Not registered in CA**	**Warning**	varroa mite	3 tbsp. per 2 gal of water. Use garden-type hand sprayer or backpack sprayer to apply. Repeat application at intervals of 7 to 10 days at 3 times per infestation. Apply at first sighting of varroa mites. Apply in early morning or late evening and not when temperature is below 55°F.
CheckMite+	coumaphos 10% (organophosphate)	11556-138	11556-138-AA-61671	**Caution**	varroa mite and small hive beetle (SHB)	For varroa control use 1 strip per 5 frames in brood chamber. For SHB control use 1 strip on cardboard at bottom of hive. Length of treatment is 42 to 45 days. Recommended use in spring (before first honey flow) and fall (after last honey flow). Cannot be used when honey supers are on.
GardStar	permethrin 40%	39039-8	39039-8-AA	**Warning**	small hive beetle (SHB)	This product is never to be used inside the hives or when bees are active, as it is highly toxic to bees. It is used as a soil drench in controlling larval SHB burrowing in the soil to pupate. For use with sprinkler can, pump, or low-pressure sprayers, use 5 ml in 1 gal water (a.i. 0.05%). For existing infestation, wet ground 18 to 24 inches around the hive (1 gal per 6 hives). Apply in the evening when bees are not active. For cleanup of apiary, drench the entire apiary surface 24 to 48 hours prior to hive placement.

(Continued)

Table 2. Pesticides used for management of various pests in honey bee colonies. Note that some pesticides listed are not registered for use in California. *(continued)*

Pesticide	Active ingredient	EPA registration no.	CDPR registration no.	California signal word(s)	Pest controlled	Quick reference application information*
HopGuard II	potassium salt of hop beta acids 16%	83623-2	83623-2-AA	**Danger**	varroa mite	1 strip per 5 frames of bees to be applied only in brood chamber. Length of treatment is 4 weeks. Can be used maximum of 3 times per year (total of 6 strips). Suggested use when brood is reduced or not present. Use permitted during honey flow.
Mite-Away Quick Strips	formic acid 46.7%	75710-2	75710-2-AA	**Danger-Poison**	varroa mite	Full dose (2 strips) or half dose (1 strip) per single brood chamber containing at least 6 frames of adult bees. Length of treatment 7 days, but no need to remove the strips. Recommended to apply in late summer or fall. Temperatures should be 50° to 85°F. Use permitted during honey flow, but do not place strips in honey supers.
Mite-A-Thol Menthol	menthol 99.94%	61671-1	61671-1-AA	**Danger**	tracheal mite	Place one packet on top bars of frames. Length of treatment is minimum 28 days. Recommended to apply in spring. Temperatures must be 60° to 80°F. Remove treatment at least 30 days prior to putting on honey supers.
Oxalic Acid Dihydrate	oxalic acid dihydrate 97.0%	91266-1	Not registered in CA	**Danger-Poison**	varroa mite	Use drenching or vaporizer methods. See label for exact application dosages. Suggested use when brood is reduced or not present. Cannot be used when honey supers are on.
Para-moth Insecticide	para-dichlorobenzene 99.94%	61671-2	Not registered in CA	**Warning**	greater wax moth	To be used for stored equipment without bees present. Recommended dose is 6 tablespoons of crystals for 5 supers. Tightly stack supers, cover any holes with tape, place crystals on a piece of paper on top bars, and tightly cover with a lid. Examine every 2 to 3 weeks. If crystals are no longer present, reapply. Air out supers thoroughly prior to adding bees.
SucraShield	sucrose octanoate 40%	70950-2-84710	Not registered in CA	**Warning**	varroa mite	No information available.

Note: *These are not pesticide application instructions. This is a quick reference guide for beekeepers to be aware of pesticides that might be available for them to use in their IPM approach. Please NOTE that some pesticides are not registered for use in California. Beekeepers should never use nonregistered chemicals, as it can be a violation of state or federal laws and can have negative consequences for bees and beekeepers. Prior to application, read the pesticide LABEL thoroughly and adhere to application instructions. A great varroa mite management resource is the Honey Bee Health Coalition's "Tools for Varroa Mite Management" guide and can be found here honeybeehealthcoalition.org/varroa/.

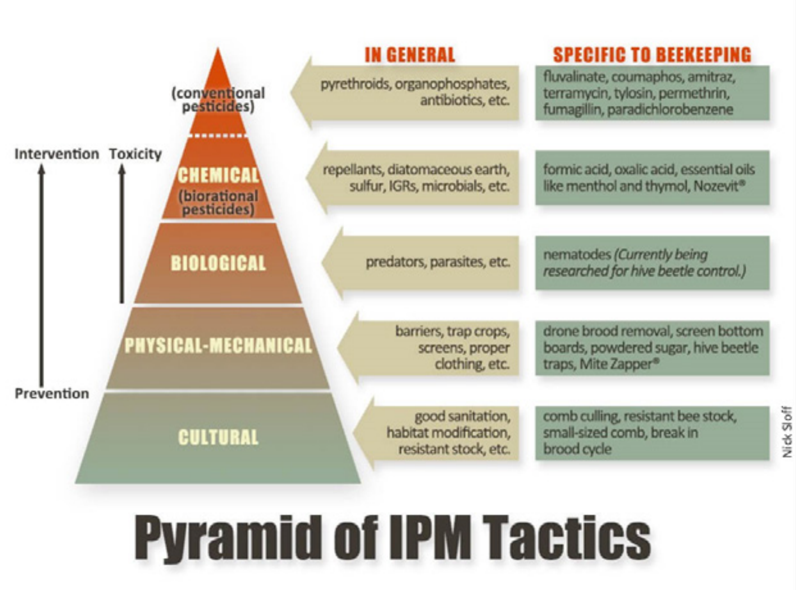

Figure 5. The pyramid of IPM tactics, showcasing various management techniques for maladies affecting honey bee colonies. The arrows indicate increasing toxicity of management strategies used, from the bottom of the pyramid (prevention) to the top of the pyramid (intervention). Please note that while biological control via microorganisms (e.g., fungi, bacteria) is often considered less harmful than the use of chemical control, it could have negative effects on nontarget organisms. *Source:* Modified with permission from Beekeeping Basics by Nick Sloff, The Pennsylvania State University, 2016.

For example, to minimize the impact of varroa mites, you can requeen a colony with hygienic bee stock (e.g., varroa-sensitive hygiene, Minnesota hygienic, etc.) and preform drone comb removal in the spring while monitoring varroa mite levels with established techniques (see the eExtension website, http://articles.extension.org/pages/33632/methods-for-varroa-sampling#.U_362sVdU7k); monthly monitoring is recommended during the active bee season). Managing varroa mites should also help minimize the impact of viral infection since many viruses can be transmitted by *Varroa*. No commercially available treatment for viral infection currently exists, although a product has been formulated but it was not widely used in the commercial market.

If a pesticide application is required, read the label before you buy the product and again before you use it, then carefully follow the label instructions to avoid unintended impacts on the colony, the environment, and the applicator. Be sure to use PPE to minimize potential negative impacts on the applicator. Remember, preventing pests in the first place is the best course of action; chemicals should be applied when pest populations are above an action or economic threshold (if established), rather than on a timed schedule (see the eExtension website, http://articles.extension.org/bee_health).

The limited use and rotation of chemicals to decrease varroa mite populations to less-harmful levels reduces possible contamination of hive products and delays the development of chemical resistance in mites. *Avoiding contaminating hive products by following pesticide label instructions to ensure consumer safety*. Limited use of miticides also reduces the exposure of bees to potentially harmful chemicals. This is especially significant because certain miticides used to kill varroa mites are known to have negative health consequences for honey bees (Johnson et al. 2010). Starting at the base of the IPM pyramid (fig. 5) and using multiple IPM tactics is safe, profitable, and environmentally friendly.

As of January 1, 2017, a new FDA (Food and Drug Administration) rule requires that beekeepers acquire a prescription or veterinary feed directive (VFD) from a veterinarian who is required to diagnose diseases in order to provide a prescription or VFD. Please note that under California Law any colonies determined to have AFB must be abated. For more information see the Food and Agriculture Code §§ 29040–29056 (https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=FAC&division=13.&title=&part=&chapter=1.&article=14.

For more information on management of *Nosema* spp., see https://articles.extension.org/pages/73564/how-is-nosema-disease-treated. For management of small hive beetle (SHB), see http://articles.extension.org/pages/60425/managing-small-hive-beetles#.U_-X2Hbp8_c

Transportation of Hives

It may be necessary to move hives for honey extraction, queen rearing, or other reasons. Colonies should be provided with excellent ventilation during the moving process and should be moved during temperate weather conditions to avoid overheating.

Prepare for the move by securing foragers inside the hive either at dawn or dusk. If the hive is closed up during the day, foragers out in the field will be left behind; this should be avoided at all costs, as it can cause nuisance for neighbors and can lead to increased agitation in returning foragers. Close up the hive by stapling a piece of no. 8 (⅛-inch) hardware cloth over the main entrance, making sure it is the correct length and fits snugly over the entrance. Inspect the hive for other entrances or gaps between boxes and cover these with duct tape or other patch material. Secure hives in the transport vehicle to prevent shifting while in transit (straps or hive staples can be helpful). Move hives to the new location as soon as possible, again limiting aggressive movements and vibrations. Open the hive once it is in position. Moving hives short distances can confuse foraging bees. To relocate a colony a short distance, first move it no less than 2 to 3 miles away, wait 2 to 3 weeks, then move the colony to the new location. Preparation and forethought will help in making the relocation successful and will avoid potential hazards, such as bee losses due to improper ventilation or hive damage from falls due to improper fastening.

Human—Bee Interactions

Bee Allergies

When agitated, bees enlist a defensive stinging behavior and inject venom into their target. They become especially agitated when their nests are disturbed. Foraging or swarming bees are unlikely to sting unless directly disturbed. Honey bee workers have a barbed stinger; when they sting, their stinger remains in the skin of the target with the venom sac and musculature, which continues to pump venom into the body. In the process of stinging, a substantial portion of the abdominal structure is pulled out, causing the bee to die. Thus, honey bee workers can each sting only once. If you are stung by a honey bee, remove the stinger immediately by scraping it to the side with your fingernail or other flat, sharp object. Honey bees also release an alarm pheromone when they sting to designate the target for other defending bees. In order to prevent the pheromone from attracting other bees, puff a bit of smoke on the area that was stung or rub dirt over the area to cover up the smell. The alarm pheromone of honey bees smells like bananas. Drones are incapable of stinging, since they do not possess a stinger; queens can sting (they do not have a barbed stinger). A sting by a queen is extremely rare.

A honey bee sting can cause two types of reactions: local and systemic. Most people exhibit a local reaction to the sting, such as swelling, redness, itchiness, and mild to moderate pain. This is normal and should subside within a few days. Placing ice on the affected area can help, as well as taking an antihistamine. However, if symptoms occur farther from the area of the sting, the reaction may be systemic; contact a physician immediately. Symptoms may include rash and itchy hives all over the body, stomach cramps, nausea, vomiting, diarrhea, dizziness, severe headache, swelling that is not in the area of the sting (particularly worrisome is swelling of the face, neck, tongue), shortness of breath or difficulty swallowing, shock, unconsciousness, or drop in blood pressure, with the most severe symptom being the inability to breathe (associated with a severe allergic reaction, or anaphylaxis). These symptoms can occur within seconds or 30 minutes after stinging incident. People who are allergic to bee venom should carry an epinephrine auto-injector with them at all times which can be obtained via a prescription from a physician. Only about 0.1 to 0.2 percent of the population (1 to 2 people out of 1,000) is severely allergic to bee stings.

For further information, see the USDA Agricultural Research Service Bee Stings website, http://www.ars.usda.gov/Research/docs.htm?docid=11067&page=1.

Bee Phobia

Fear and anxiety are distressing emotions stimulated by real or imagined danger, evil, or pain. Phobias, the persistent and illogical fear of specific objects, activities, and situations, are common, with concerns regarding animals being among the most common of all. Pain and swelling associated with stings from venomous insects, the issue of mass envenomization (especially associated with Africanized honey bees), and problems of sting-related allergies can promote a fear of bees, hornets, and wasps (Mathew et al. 2011; West et al. 2011). Münstedt and Mühlhans (2013) surveyed and analyzed peoples' views about various arthropods in relation to potential dangers and ecological and economic benefits, with an emphasis on the honey bee. Their questionnaire differentiated between the reasonable and rational aspects of dangers associated with arthropods and emotional fear. Stinging Hymenopterans (hornets, wasps, and bees) were considered to be the most dangerous arthropods, while hornets and spiders produced the highest levels of anxiety and disgust from respondents. However, Münstedt and Mühlhans (2013) found that the more knowledge people had about the arthropods, the less disgust they had toward the animals.

Therefore, improving knowledge about arthropods such as honey bees and their ecological and agricultural importance should be a useful approach to reducing people's anxiety and disgust. Generally, negative interactions between people and honey bees can be avoided by watching for "flight paths." If there is back-and-forth flight traffic to and from a specific spot, it is likely that insects are nesting there. It is a good place to avoid. These are important considerations for beekeepers, who are sometimes confronted by anxious and frustrated neighbors who insist that bees be removed. Understanding people's concerns and using this opportunity to educate them about the importance of honey bees and their value to our natural world may lead to a greater acceptance of backyard beekeeping. Providing a jar of your own honey to the neighbors can go a long way as well!

Glossary

absconding. The total adult population abandoning of a nest or hive at once.

apiary. A place where honey bee hives with living colonies are kept.

apiarist. A professional or amateur manager of hived honey bee colonies.

apiculture. The management of hived honey bee colonies.

bee colony. Sensu stricto: All living members of the honey bee population, including eggs, larvae, pupae, and thousands of adults. Sensu lato: All living members of the honey bee colony plus the hive, combs, stored pollens, and honey.

beehive (hive). The enclosed space in which a bee colony is living. For beekeeping purposes, a removable-frame housing for a honey bee colony.

beekeeper. *See* apiarist.

beekeeping. *See* apiarist.

beeswax. Substance formed by the conversion of sugar to wax in the abdominal wax glands of worker honey bees.

brand. Beekeeper-specific identification code for marking hives, frames, and other beekeeping equipment.

brood chamber or **brood box**. Bee boxes in which brood rearing (eggs, larvae, pupae) occurs.

brood food. Glandular secretions from nurse bees fed to developing larvae. For example, royal jelly is produced by workers and fed to larvae destined to become queens. Worker food, a mixture of glandular secretions, pollen, and honey, is fed to larvae destined to become workers.

economic threshold. Density of a pest or level of infestation at which the treatment will yield economic returns or at which the cost of damage or loss would cost more than the cost of treatment.

ecosystem services. Services such as pollination provided by nature (e.g., honey bees) that benefit humans.

flight path. The route taken by many bees leaving or returning to their hive.

foraging bees (foragers). Bees seeking water, food, or propolis.

hive. *See* beehive.

hive products. Products either collected, produced, or processed by honey bees and used for human consumption or other purposes, including but not limited to honey, beeswax, pollen, propolis, and royal jelly.

hive staples. Long staples, (typically 2") used diagonally across hive body junctions to prevent boxes from shifting during hive transportation.

honeycomb (comb). Formation of six-sided beeswax cells (often within a frame inside a hive) housing honey, pollen, nectar, or immature stages of honey bees.

honey. A concentrated sugar solution originating from nectar secreted by plants and sucking insects, which is collected, processed and dehydrated by honey bees.

honey extraction. The removal of honey from combs for human consumption.

honey flow. A period of the season during which nectar is abundant enough to exceed the daily consumption by individual bees and is processed into and stored as honey inside honeycombs as a food resource.

honey super. Box or boxes containing frames placed above brood boxes or brood chamber and separated by a queen excluder for collection of honey.

nucleus colony. A small, three- to five-frame beehive containing a queen, workers, drones, brood, etc.

package bees. A number of adult bees (2-3 pound packages are most common), with or without a queen, contained in an enclosed, ventilated shipping cage (also containing a sugar source) for transportation.

pollination. The transfer of pollen by bees from anthers to stigmas of flowers for the purpose of plant fertilization.

propolis. A resin-like mix of bee saliva, beeswax, and substances gathered from plants that bees use for sealing and maintenance in hives.

robbing. Bees taking food stores from another colony in order to store it in their own nest.

royal jelly. A milky liquid secreted by honey bees containing proteins, sugars, and other substances that is fed to bee larvae.

strong colony. A populous honey bee colony.

super. A bee box placed above the brood chamber.

swarm. A flying mass (sometimes a stationary cluster) of adult honey bees, including workers, queen, and drones, attempting to locate a new home; a natural process of colony reproduction.

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