# Beekeeping Basics

MAAREC: Delaware, Maryland, New Jersey, Pennsylvania, West Virginia, and the USDA cooperating

PennState Extension

# Contents




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Front cover photos courtesy of Maryann Frazier; back cover photo courtesy of Steve Williams.

MAAREC

Mid-Atlantic Apiculture Research and Extension Consortium

# Introduction

Beekeeping can be a fascinating hobby, a profitable sideline, or a full-time occupation. You may want to keep bees for the delicious fresh honey they produce, for the benefits of their valuable services as pollinators, or perhaps simply for the enjoyment of learning more about one of nature's most interesting insects.

Almost anyone can keep bees. Honey bees normally only sting to defend themselves or their colony; when colonies are handled properly and precautions are taken, stinging is not a major problem. Most beekeepers develop a tolerance for bee venom over time and have reduced sensitivity to pain and swelling. However, the few people who react strongly to bee stings and pollen or who are unable to get over fears of stings should avoid contact with bees.

Most beekeepers in the Mid-Atlantic region are hobbyists. Beekeeping is generally considered a minor industry. However, because of its interrelationship with agriculture and dependency of growers of several commodities on honey bee pollination, beekeeping is much more important than merely the value of the beeswax and honey produced annually.

This manual is all about beekeeping—understanding honey bee biology, getting started, managing bee colonies for fun and/or profit—and is designed to help you become a successful beekeeper. Welcome to the world of beekeeping.

# The Colony and Its Organization

Honey bees are social insects, which means that they live together in large, well-organized family groups. Social insects are highly evolved insects that engage in a variety of complex tasks not practiced by the multitude of solitary insects. Communication, complex nest construction, environmental control, defense, and division of the labor are just some of the behaviors that honey bees have developed to exist successfully in social colonies. These fascinating behaviors make social insects in general, and honey bees in particular, among the most fascinating creatures on earth.

A honey bee colony typically consists of three kinds of adult bees: workers, drones, and a queen (Figure 1). Several thousand worker bees cooperate in nest building, food collection, and brood rearing. Each worker has a definite task to perform, related to its adult age. But surviving and reproducing take the combined efforts of the entire colony. Individual bees (workers, drones, and queens) cannot survive without the support of the colony.

In addition to thousands of worker adults, a colony normally has a single queen and several hundred drones during late spring and summer. The social structure of the colony is maintained by the presence of the queen and workers and depends on an effective system of communication. The distribution of chemical pheromones among members and communicative "dances" are responsible for controlling the activities necessary for colony survival. Labor activities among worker bees depend primarily on the age of the bee but vary with the needs of the colony. Reproduction and colony strength depend on the queen, the quantity of food stores, and the size of the worker force. As the size of the colony increases up to a maximum of about 60,000 workers, so does the efficiency of the colony.

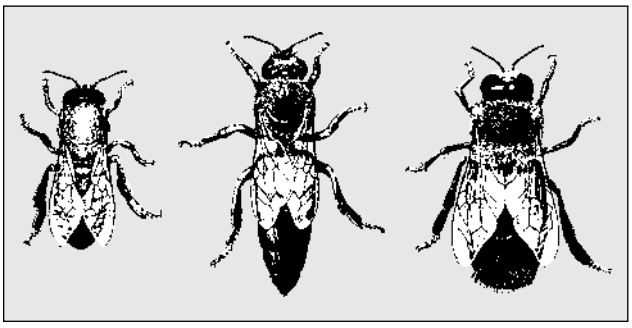


**Figure 1. Three types of honey bees normally found in a honey bee colony: worker, queen, and drone. (Courtesy of the U.S. Department of Agriculture)**

## Queen

Each colony has only one queen, except during and a varying period following swarming preparations or supersedure. Because she is the only sexually developed female, her primary function is reproduction. She produces both fertilized and unfertilized eggs. Queens lay the greatest number of eggs in the spring and early summer. During peak production, queens may lay up to 1,500 eggs per day. They gradually cease laying eggs in early October and produce few or no eggs until early next spring (January). One queen may produce up to 250,000 eggs per year and possibly more than a million in her lifetime.

A queen is easily distinguished from other members of the colony. Her body is normally much longer than either the drone's or worker's, especially during the egg-laying period when her abdomen is greatly elongated. Her wings cover only about two-thirds of the abdomen, whereas the wings of both workers and drones nearly reach the tip of the abdomen when folded. A queen's thorax is slightly larger than that of a worker, and she has neither pollen baskets nor functional wax glands. Her stinger is curved and longer than that of the worker, but it has fewer and shorter barbs. The queen can live for several years—sometimes for as long as 5, but average productive life span is 2 to 3 years.

The second major function of a queen is producing pheromones that serve as a social "glue" unifying and helping to give individual identity to a bee colony (Figure 2, next page). One major pheromone—termed queen substance—is produced by her mandibular glands, but others are also important. The characteristics of the colony depend largely on the egg-laying and chemical production capabilities of the queen. Her genetic makeup—along with that of the drones she has mated with—contributes significantly to the quality, size, temperament, and productivity of the colony.

About one week after emerging from a queen cell, the queen leaves the hive to mate with several

**Figure 2. Queen surrounded by attendant workers. Although unique in shape and size, the queen is recognized by works and drones, not by the way she looks, but by her "chemical signature" or pheromone called queen substance.**

drones in flight. Because she must fly some distance from her colony to mate (nature's way of avoiding inbreeding), she first circles the hive to orient herself to its location. She leaves the hive by herself and is gone approximately 13 minutes. The queen mates, usually in the afternoon, with seven to fifteen drones at an altitude above 20 feet. Drones are able to find and recognize the queen by her chemical odor (pheromone). If bad weather delays the queen's mating flight for more than 20 days, she loses the ability to mate and will only be able to lay unfertilized eggs, which result in drones.

After mating, the queen returns to the hive and begins laying eggs in about 48 hours. She releases several sperm from the spermatheca each time she lays an egg destined to become either a worker or queen. If her egg is laid in a larger drone-sized cell, she normally does not release sperm, and the resulting individual becomes a drone. The queen is constantly attended and fed royal jelly by the colony's worker bees. The number of eggs the queen lays depends on the amount of food she receives and the size of the worker force capable of preparing beeswax cells for her eggs and caring for the larva that will hatch from the eggs in 3 days. When the queen substance secreted by the queen is no longer adequate, the workers prepare to replace (supersede) her. The old queen and her new daughter may both be present in the hive for some time following supersedure.

New (virgin) queens develop from fertilized eggs or from young worker larvae not more than 3 days old. New queens are raised under three different circumstances: emergency, supersedure, or swarming. When an old queen is accidentally killed, lost, or removed, the worker bees select younger worker larvae to produce emergency queens. These queens are raised in worker cells modified to hang vertically on the comb surface (Figure 3). When an older queen begins to fail (decreased production of queen substance), the colony prepares to raise a new queen. Queens produced as a result of supersedure are usually better than emergency queens since they receive larger quantities of food (royal jelly) during development. Like emergency queen cells, supersedure queen cells typically are raised on the comb surface. In comparison, queen cells produced in preparation for swarming are found along the bottom margins of the frames or in gaps in the beeswax combs within the brood area.

## Drones

Drones (male bees) are the largest bees in the colony. They are generally present only during late spring and summer. The drone's head is much larger than that of either the queen or worker, and its compound eyes meet at the top of its head. Drones have no stinger, pollen baskets, or wax glands. Their main function is to fertilize the virgin queen during her mating flight, but only a small number of drones perform this function. Drones become sexually mature about a week after emerging and die instantly upon mating. Although drones perform no useful work for the hive, their presence is believed to be important for normal colony functioning.

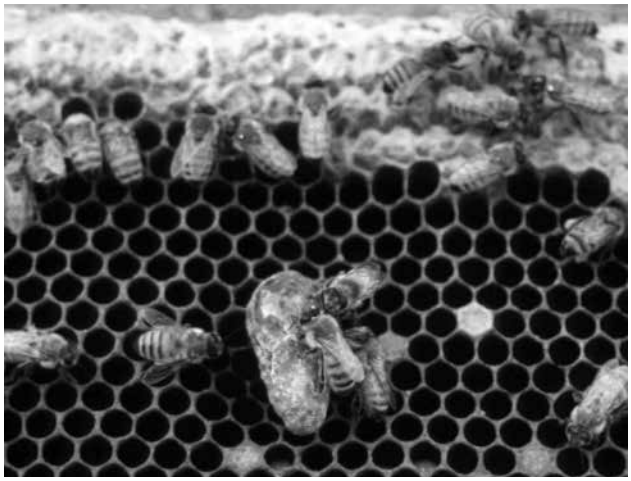


**Figure 3. Emergency queen cell built by workers by modifying an existing worker cell to accommodate the larger size of the queen. (Courtesy Maryann Frazier)**

While drones normally rely on workers for food, they can feed themselves within the hive after they are 4 days old. Since drones eat three times as much food as workers, an excessive number of drones may place an added stress on the colony's food supply. Drones stay in the hive until they are about 8 days old, after which they begin to take orientation flights. Flight from the hive normally occurs between noon and 4:00 P.M. Drones have never been observed taking food from flowers.

When cold weather begins in the fall and pollen/nectar resources become scarce, drones usually are forced out into the cold and left to starve. Queenless colonies, however, allow them to stay in the hive indefinitely.

## Workers

Workers are the smallest bodied adults and constitute the majority of bees occupying the colony. They are sexually undeveloped females and under normal hive conditions do not lay eggs. Workers have specialized structures, such as brood food glands, scent glands, wax glands, and pollen baskets, which allow them to perform all the labors of the hive. They clean and polish the cells, feed the brood, care for the queen, remove debris, handle incoming nectar, build beeswax combs, guard the entrance, and air-condition and ventilate the hive during their initial few weeks as adults. Later as field bees they forage for nectar, pollen, water, and propolis (plant sap).

The life span of the worker during summer is about 6 weeks. Workers reared in the fall may live as long as 6 months, allowing the colony to survive the winter and assisting in the rearing of new generations in the spring before they die.

**Figure 4. Eggs laid by workers (laying workers) in a queenless colony. (Courtesy Scott Camazine)**

## Laying Workers

When a colony becomes queenless, the ovaries of several workers develop and workers begin to lay unfertilized eggs. Normally, development of the workers' ovaries is inhibited by the presence of brood and the queen and her chemicals. The presence of laying workers in a colony usually means the colony has been queenless for several weeks. However, laying workers also may be found in normal "queenright" colonies during the swarming season and when the colony is headed by a poor queen. Colonies with laying workers are recognized easily: there may be anywhere from five to fifteen eggs per cell (Figure 4) and small-bodied drones are reared in worker-sized cells. In addition, laying workers scatter their eggs more randomly over the brood combs, and eggs can be found on the sides of the cell instead of at the base, where they are placed by a queen. Some of these eggs do not hatch, and many of the drone larvae that do hatch do not survive to maturity in the smaller cells.

## Bee Development

All three types of adult honey bees pass through three developmental stages before emerging as adults: egg, larva, and pupa. The three stages are collectively labeled brood. While the developmental stages are similar, they do differ in duration (see Table 1). Unfertilized eggs become drones, while fertilized eggs become either workers or queens. Nutrition plays an important part in caste development of female bees; larvae destined to become workers receive less royal jelly and more a mixture of honey and pollen compared to the copious amounts of royal jelly that a queen larva receives.

**Table 1. Developmental stages of the three castes of bees.**

| DEVELOPMENTAL STAGE | DURATION OF STAGES | | |
|---|---|---|---|
| | QUEEN | WORKER | DRONE |
| | Days | | |
| Egg | 3 | 3 | 3 |
| Larval stage | 5 ½ | 6 | 6 ½ |
| Pupal stage | 7 ½ | 12 | 14 ½ |
| Total developmental time | 16 | 21 | 24 |

## Brood

### EGGS

Honey bee eggs are normally laid one per cell by the queen. Each egg is attached to the cell bottom and looks like a tiny grain of rice (Figure 5). When first laid, the egg stands straight up on end. However, during the 3-day development period the egg begins to bend over. On the third day, the egg develops into a tiny grub and the larval stage begins.

### LARVAE

Healthy larvae are pearly white in color with a glistening appearance. They are curled in a "C" shape on the bottom of the cell (Figure 6). Worker, queen, and drone cells are capped after larvae are approximately 6, 5½, and 6½ days old, respectively. During the larval stage, they are fed by adult worker (nurse) bees while still inside their beeswax cells. The period just after the cell is capped is called the prepupal stage. During this stage the larva is still grub-like in appearance but stretches itself out lengthwise in the cell and spins a thin silken cocoon. Larvae remain pearly white, plump, and glistening during the prepupal stage.

### PUPAE

Within the individual cells capped with a beeswax cover constructed by adult worker bees, the prepupae begin to change from their larval form to adult bees (Figure 7). Healthy pupae remain white and glistening during the initial stages of development, even though their bodies begin to take on adult forms. Compound eyes are the first feature that begin to take on color; changing from white to brownish-purple. Soon after this, the rest of the body begins to take on the color of an adult bee. New workers, queens, and drones emerge approximately 12, 7½, and 14½ days, respectively, after their cells are capped.

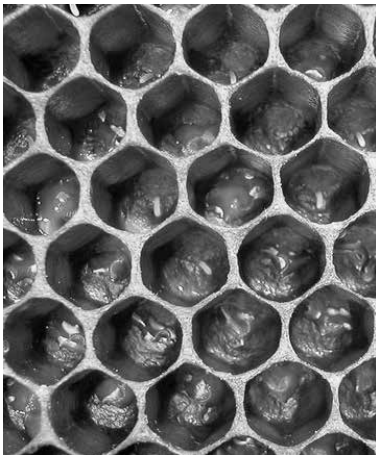


**Figure 5. Cells with fertilized eggs laid by the queen. (Courtesy Maryann Frazier)**

### BROOD PATTERNS

Healthy brood patterns are easily recognized when looking at capped brood. Frames of healthy capped worker brood normally have a solid pattern with few cells missed by the queen in her egg laying. Cappings are medium brown in color, convex, and without punctures (Figure 8). Because of developmental time, the ratio should be four times as many pupae as eggs and twice as many as larvae; drone brood is usually in patches around the margins of brood nest.

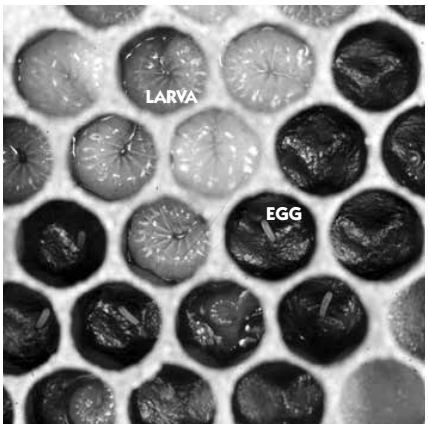



**Figure 6. Cells with healthy worker larvae. (Courtesy Dewey Caron)**

**Figure 7. Honey bee pupae changing from the larval to adult form. (Courtesy Scott Camazine)**

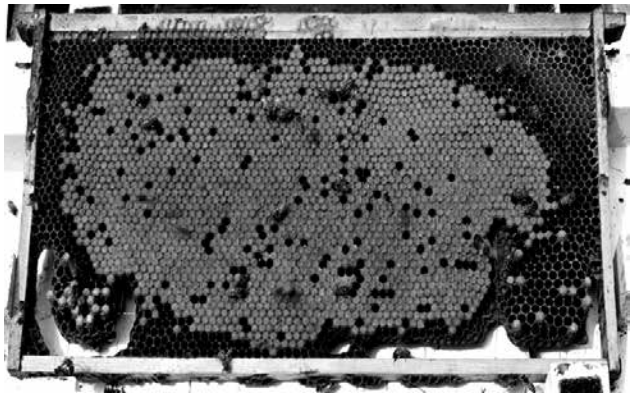


**Figure 8. Comb of sealed worker brood with drone cells in the lower corners. (Courtesy Maryann Frazier)**

# Beekeeping Equipment

Equipment needs vary with the size of your operation, number of colonies, and the type of honey you plan to produce. The basic equipment you need are the components of the hive, protective gear, smoker and hive tool, and the equipment you need for handling the honey crop.

The hive is the man-made structure in which the honey bee colony lives. Over the years a wide variety of hives have been developed. Today most beekeepers in the United States use the Langstroth or modern ten-frame hive. A typical hive consists of a hive stand, a bottom board with entrance cleat or reducer, a series of boxes or hive bodies with suspended frames containing foundation or comb, and inner and outer covers (Figure 9, next page, includes dimensions for those wishing to construct their own hives). The hive bodies that contain the brood nest may be separated from the honey supers (where the surplus honey is stored) with a queen excluder.

## The Hive

### HIVE STAND

The hive stand, actually an optional piece of equipment, elevates the bottom board (floor) of the hive off the ground. In principle, this support reduces dampness in the hive, extends the life of the bottom board, and helps keep the front entrance free of grass and weeds. Hive stands may be concrete blocks, bricks, railroad ties, pallets, logs, or a commercially produced hive stand. A hive stand may support a single colony, two colonies, or a row of several colonies.

### BOTTOM BOARD

The bottom board serves as the floor of the colony and as a takeoff and landing platform for foraging bees. Since the bottom board is open in the front, the colony should be tilted forward slightly to prevent rainwater from running into the hive. Bottom boards available from many bee supply dealers are reversible, providing either a $\frac{7}{8}$- or $\frac{3}{8}$-inch opening in front.

### HIVE BODIES

The standard ten-frame hive body is available in four common depths or heights. The full-depth hive body, $9\frac{5}{8}$ inches high, is most often used for brood rearing. These large units provide adequate space with minimum interruption for large solid brood areas. They also are suitable for honey supers. However, when filled with honey, they weigh over 60 pounds and are heavy to handle.

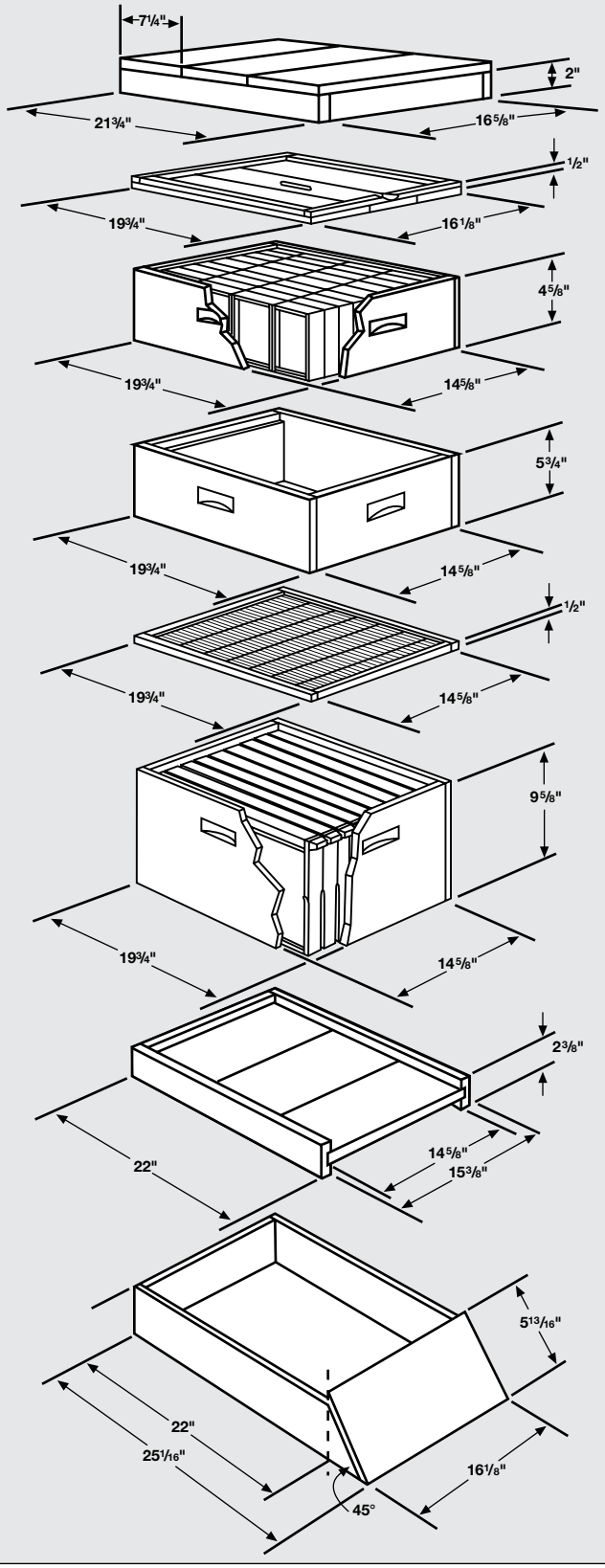
The medium-depth super, sometimes called the Dadant or Illinois super, is $6\frac{5}{8}$ inches high. While this is the most convenient size for honey supers, it cannot be cut efficiently from standard-sized lumber. An intermediate size ($7\frac{5}{8}$ inches) between the full- and medium-depth super is preferred by some beekeepers, especially those who make their own boxes.

The shallow-depth super, $5\frac{1}{16}$ inches high, is the lightest unit to manipulate (about 35 pounds when filled with honey). This size has the greatest cost of assembly per square inch of usable comb space.

Section comb honey supers, $4\frac{5}{8}$ inches high, hold either basswood section boxes or plastic rings and section holders. Section comb honey production is a specialized art requiring intense management and generally is not recommended for beginners.

Some beekeepers prefer eight-frame hive bodies. These were mostly homemade, but one U.S. bee supplier is now selling eight-frame boxes as English garden hive boxes. Beekeepers rearing queens and/or selling small starter colonies (nucs) prefer to use a three- or five-frame nuc box usually with standard deep frames. These can be purchased from bee supply dealers and are constructed from wood or cardboard, the latter for temporary use only.

Different management schemes are used according to the depth of hive bodies utilized for the brood area of the hive. One scheme is to use a single full-depth hive body, which theoretically would give the queen all the room she needs for egg laying. However, additional space is needed for food storage and maximum brood nest expansion. Normally a single full-depth brood chamber is used when beekeepers want to crowd bees for comb honey production, when a package is installed, or when a nucleus colony or division is first established. Most beekeepers elect to use either two full-depth hive bodies or a




**Outer Telescoping Cover**

3 pieces 7¼" X ¾" X 18⅛" (top)
2 pieces 21¾" X ¾" X 2" (sides)
2 pieces 16⅜" X ¾" X 2" (ends)

**Inner Cover**

2 pieces ½" X ¾" X 16⅛"
2 pieces ½" X ¾" X 18¼"
2 pieces 6" X ⅜" X 19¾"
1 piece 4⅛" X ⅜" X 19¾"

**Section Comb Super**

2 pieces 19¾" X ¾" X 4⅝" (sides)
2 pieces 14⅝" X ¾" X 4⅝" (ends)

**Shallow Extracting Super**

2 pieces 19¾" X ¾" X 5¾" (sides)
2 pieces 14⅝" X ¾" X 5¾" (ends)

**Queen Excluder**

2 pieces 19¾" X ¾" X 5¾" (sides)
2 pieces 14⅝" X ¾" X 5¾" (ends)

**Full Depth Hive Body**

2 pieces 19¾" X ¾" X 9⅝" (sides)
2 pieces 14⅝" X ¾" X 9⅝" (ends)

**Bottom Board**

3 pieces 7⅛" X ¾" X 15⅜" (floor)
2 pieces 2⅜" X ¾" X 22" (sides)
1 piece 2⅜" X ¾" X 14⅝" (end)

**Hive Stand**

1 piece 3" X ¾" X 14⅝" (back end)
2 pieces 3" X ¾" X 25 1/16" (sides)
1 piece 5 3/16" X ¾" X 16⅛" (front end)

ILLUSTRATION BY PETER KAUFFMAN

**Figure 9. Equipment and dimensions for a standard Langstroth hive.**

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