

QUEEN BEE 101

Biology and Behavior of Queen Bees

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Who decides queen activities?

New beekeepers are quick to assume that the queen bee is in charge of her fate inside the hive, but the truth is that she is does not determine her own activities, at least not directly, but is responsive to the needs of the entire colony. Queen feeding, waste removal, and superseding replacement are all the results of the collaborative decision-making nature of worker bees. These decisions are based on chemical information (feedback) the bees receive from the body of the queen. The queen's body produces queen pheromone and hormones that bees respond to. She also produces eggs – both open and sealed brood that influences worker bee behavior. It is a complex arrangement. The queen directly decides very little, but her behavior and core biology determine much of the colony's future and indirectly her own.

Developmental time and what it means

Queen bees are one of two female castes of bees found inside the hive, the other cast being the worker bees. Drones are male bees, and are not a caste, but the male sex. Queens and worker bees develop from apparently identical eggs that are deposited into a cell by their mother queen following successful mating with multiple drones, and have two sets of chromosomes, and thus are *diploid* individuals. Worker bees are unable to mate, thus in queenless and broodless situations produce eggs with a single set of chromosomes. In bees and other social hymenoptera individuals with one set of chromosomes develop into males, and are thus haploid.

Queen bees have the shortest developmental time, running 15.5 to 16 days from the time the egg is placed

into the cell to emergence of the new queen from the queen cell. Some strains have shorter developmental times, and African queens are known to develop in just 14 days.

Once a queen emerges from the cell she will feed herself and be fed by nurse bees inside the hive. After a week or so the queen will make orientation flights and then mating flights, usually mating with 12 to 20 different drones. After several days of grooming and feeding by nurse bees inside the hive the queen will start to lay eggs into worker cells emptied and polished by the bees in the brood nest. Once a queen starts to lay eggs she does not mate again, meaning that any shortage of sperm will not be corrected, and the fate of the queen, and perhaps the hive, is set.

In Nature old and inferior queens are replaced through the superseding process. When the queen's pheromone production drops to about half of its normal level (and the amount of brood also drops), then certain larvae are selected, their cells are enlarged, and the peanut shaped queen cell is built on the surface of the comb. There are usually only three to nine superseding cells produced in the average colony, and the cells may be located anywhere on the surface of the brood frame. Worker bees combine their skills to produce queen cells, for it requires nurse bees for the production of royal jelly, and house bees for the secretion of honey to produce beeswax and sculpt the queen cell. Other bees are concerned with temperature stability to insure proper queen development.

Mating, egg-laying and sperm storage

Queens and drones fly on warm and calm afternoons during normal flight periods. They travel to Drone Congregation Areas where the queen is receptive to the many drones that follow her pheromone plume and her dark form against the sky. DCAs may be located anywhere around an apiary, and can be found by careful tracking with helium balloons, kites or radar. Mating occurs 50 to 150 feet off the ground, and are thus rarely seen by humans.

Queen bees produce about 150,000 eggs per year, and depend upon two large ovaries (often nearly filling the abdomen) filled with about 370 thin tubes called ovarioles, that produce eggs on a continuous basis. In the peak of the season a queen will produce about 1,500 eggs per day, although larger numbers have been reported. These may be due to a sudden burst of activity by a queen that is being stimulated by very favorable weather, food supply and genetic programming. Reports of queens with egg-laying rates of 3,000 may be a reflection of a second queen in the colony (the mother queen and her superseding daughter, an event that occurs in over 10 percent of vigorous Spring colonies.)



Virgin queen lacks the swelling of the abdomen that laying queens possess.

Queens store the sperm from the multiple drones in a clear, fluid-filled sac or sphere located near the tip of her abdomen called the spermatheca. This structure is covered with a fine network of breathing tubes, called trachea, that bring oxygen to the sperm stored there. The spermatheca floats in the blood of the queen, and receives constant nutrition. The spermatheca holds five to eight million sperm, but a failing queen may have only a few thousand sperm, and can be identified by drone cells within the worker brood pattern in the hive.

We are not sure how a queen determines when she has mated with an adequate number of drones, but when she has finished her reproductive flights her median and two lateral oviducts are filled with sperm. The nurse bees massage her body and remove the drones' sexual fluids, while about 10 percent of the sperm successfully migrate through a spermathecal duct into the spermatheca.

In one to four days the queen will begin to deposit eggs into worker prepared cells.

Longevity of queens

Some queens only live for a few weeks when the worker bees decide for reasons we do not completely understand to replace the queen with another. Sometimes queens stop laying eggs after several days, and no queen cells are produced from the eggs and larvae in the hive. Other queens will produce a good brood pattern for several weeks when the colony decides to replace her with a daughter queen.

Once a queen is well established in a hive we expect her to remain for a year or more. Some reports of older queens are common, some as long as five years. Commercial beekeepers replace queens at least once a year (in Southern locations and migratory operations) or less often in non-migratory, Northern operations. Small-scale beekeepers will keep queens in a hive for a longer time period as long as the queen continues to perform well for the colony. Bee breeders attempt to select queens that maintain egg laying for as long as possible, in the attempt to select for genetic longevity within the bloodline. With selection, breeders keep productive queens for five years.

Behavior of Queens and Workers

Queen cells and worker bees – As queen cells develop, the fully formed adult queen confined inside the queen cell produces some of the chemicals that make up part of her queen odor or queen substance (pheromones). Worker bees surrounding the queen cell (keeping it warm) remove the wax tip of the queen cell to expose the silk cocoon tip. It is widely thought that the workers will keep these cells under closed surveillance, monitoring the development of the queen inside the cells. When the queen is ready to emerge she will use her sharp mandibles to cut her way out of the cells. Almost immediately she will move to other queen cells, her sisters, and chew a hole into the side with her mandibles and then sting the queen inside the cell. Worker bees do not interfere with this behavior, but remove the dead queen and her cell after a time period.

Sometimes supernumerary queens are produced in a colony and are held hostage inside the queen cell until the bees determine the proper time for their emergence. The worker bees add beeswax to the incision the queen makes



Laying queen with large body size. Does this make her a good queen? Her colony was loaded with chalk brood, so my answer is NO!

to cut herself free from the cell. However, the workers are careful to feed such a queen to keep her healthy.

Newly emerged queens – After a newly emerged queen has finished killing her sisters, she moves rapidly over the combs. She does not yet have the pheromone production she will have as a laying queen, and for the first 12 hours or so her odor level is quite reduced. After twelve hours her odor production is enough for the workers to respect her as an unmated queen, and to attract drones to her in the DCA for multiple mating.

Some beekeepers use smoke, strong odors and other techniques to introduce virgin queens. These may work under certain conditions, but as a general rule, virgin queens should be introduced in a queen cage with a candy release plug or a push-in cage. These are the same methods used for a mated queen. With virgin queens there are two additional risks. First, virgin queens are able to fly and often do, causing a loss. Second, the queen has pheromones of a queen and should be treated as a queen and not a young nurse bee from another colony.

Virgin queens at the time of mating – Worker bees fly with the queens when they leave for the mating flight. I have not learned of a reason for this mating swarm, but it is common in other social insects. Perhaps it is a method of increasing security against predators. Back at the colony, there is a change in the behavior of the house bees as mating is underway. The bees no longer store pollen and nectar in the key brood cells, but remove the food by eating it, stimulating both royal jelly and wax production. The emptied cells are cleaned and polished to provide a place for the queen to lay. The sharp-eyed beekeeper may not be able to find the queen before her abdomen starts to swell with egg laying. (This is a hormonal response to the mating process.) Once there is a large area of polished brood cells, it is likely that there will be eggs in those cells in a day or two. From the time of the last mating flight to the first eggs queens may require one to three days for the hormonal changes to take place and for heavy feeding by workers to begin to stimulate egg production.

Newly mated queens – It takes at least four weeks for a queen to fully mature from the time she emerges, mates and starts to lay. During this month-long period it is possible to disrupt the delicate balance between the queen and her colony (remember, these bees are not her daughters until the first brood emerges at three weeks).

When the queen's pheromone production drops to about half of its normal level then certain larvae are selected, their cells are enlarged, and the peanut shaped queen cell is built on the surface of the comb.

If the queen has been introduced to the colony from another source, she may not even be genetically related to the queen, and the balance is even more fragile. There are reports of poor introduction and early rejection of queens introduced into unrelated stocks, like putting a dark-race queen into a yellow Italian hive. There are undoubtedly genetically determined variations in pheromone production as well as key queen behaviors that worker bees monitor and we know very little about!

Laying queens – Once established queens may be checked every two to four weeks to make sure she is doing her job. We will discuss queen finding later, but I like to have a queen that is clipped and/or marked and then rely upon the presence of eggs and young larvae and a nice brood pattern as evidence that she is doing her job. Some colonies may only require a queen check once or twice a year for many small-scale beekeepers. And less than that for commercial beekeepers.

Grand Old Ladies! – We all develop favorite queens and may want to have a set schedule of queen replacement. I view older queens, those two years or older, as Grand Old Ladies that must get some respect when they continue to produce a quality brood pattern and a gentle,

productive, Winter-hearty hive. She can be converted over to drone production if she is not used for grafting, for you want these traits increased in you apiary – it is a never-ending challenge in beekeeping.

Sometimes beekeepers move these older queens into smaller hives and keep an eye on them and use them for grafting. A double five-frame nucleus is great for this. The older queen can be used to establish a five-frame nucleus and then a super added as the colony expands. Removing a frame of graftable larvae will reduce the population of the hive (I put the extra open brood into the cell builder colony), and keep the older queen in balance with her reduced egg laying. Pull out frames with superseded cells and produce nuclei with them to keep her genetics in your apiary. This is part of the Art of Beekeeping that provides me with so much satisfaction. Letting these Grand Old Ladies die a natural death seems like a fair trade for a number of highly productive seasons. It has nothing to do with being a businessperson, but a great deal about your appreciation of genetic diversity, longevity and productivity.

Next month we will deal with issues of finding the queen, replacing and introducing queens (especially in the Summer months), and a discussion of managing queens in packages, nuclei hives and a wide range of queen problems. **BC**

Dr. Connor will be teaching a queen rearing class in Michigan this month, so check www.wicwas.com for details. For more information on bee reproduction, consult a copy of Bee Sex Essentials.