Honey Bee Queen Biology

The honey bee queen is essential for the survival and productivity of a colony. Under normal conditions, the queen is the only reproductive female in the colony. Her primary role is laying eggs; she can lay over 1500 eggs a day during peak brood production. She also releases pheromones that regulate the behaviour of the workers. Furthermore, as the only reproductive female, her genes influence the genes of the whole colony, so it is important to invest in high quality queens.

Queen life cycle and mating

A queen bee can be raised by the workers from any female (fertilized) egg. Like any bee, a queen develops inside a cell. However, a queen is too large to fit inside a normal brood cell, so a special queen cell will be built hanging vertically from a frame.

The queen will emerge from the queen cell after 16 days. At this point, she is unmated and is referred to as a virgin queen. Virgin queens are slightly smaller and move faster than mated queens. In order to become mated, she will go on several mating flights throughout the first 2 weeks post-emergence. During these mating flights, she exits the hive and flies to a Drone Congregation Area (DCA), where she will mate with multiple drones. A queen will only undergo one mating period in her lifetime. She will store the drones' sperm cells in an organ called the spermatheca, and use these stored sperm cells to fertilize her eggs throughout her lifetime. A mated queen can begin laying eggs around 2-3 days after her mating period has finished. A queen can live for up to 6 years, but is more likely to live for just 2-3 years.

Q: What's the difference between a worker egg and a queen egg?

A: Nothing! All female eggs are the same. The difference lies in how they are treated by the workers during the larval stage. A developing worker will only be fed royal jelly at the beginning of its development period. Royal jelly is a nutritionally-rich substance secreted by worker bees and fed exclusively to young brood. A larva being raised into a queen will be fed royal jelly for its entire development period. These extra nutrients and hormones will allow the queen to develop a fully functioning reproductive system, whereas workers only have an undeveloped reproductive system.

Queen Cups

The presence of queen cups and/or cells can reveal a lot about what is going on inside the hive. It is critical that beekeepers are able to differentiate between the different stages of queen cells. The beginning stage of a queen cell is called a queen cup (Figure 1). A queen cup is round, and can be smooth or textured. A queen cup will have an opening at the bottom. The presence of queen cups does not necessarily mean that the colony is trying to raise a new queen; workers will routinely build queen cups just to have on hand.

Figure 1. A queen cup.

Q: How can I tell if the colony is trying to raise a new queen?

A: If you see a young larva sitting inside the queen cup on a bed of royal jelly (Figure 2), that is a sure indication that a new queen is being raised. If you see an egg inside a queen cup, there is a high probability that a new queen is being raised. However, it is possible that this will be torn down by the workers, and no new queen will be raised. It is safer to assume that eggs are an indication of a new queen being raised, especially if you find multiple queen cups with eggs.

Figure 2. A larva sitting on a bed of royal jelly inside a queen cup.

Once an egg has been laid, the workers will begin to draw the cup out into a queen cell. A queen cell will have a rough texture resembling a peanut shell. The queen cell will remain open at the bottom during the larval stage, then be capped over just before the pupal stage (Figure 3)

Figure 3. A capped queen cell.

Emerged Cells

An emerged queen cell – a cell from which a queen has already exited – will be open at the bottom (Figure 4). The opening will have a slightly rough, chewed appearance around the edges. Sometimes, the capping "lid" will still be attached at the bottom. In both cases, the cell will be empty inside.

Figure 4. An emerged queen cell.

A colony will typically raise multiple queen cells at once. The first virgin queen to emerge will usually move through the hive, killing the other unemerged queens. If more than one virgin queen emerges at once, they will fight to the death. When a queen has been killed prior to emergence, the workers will tear down the queen cell. In this case, the cell will have a large, irregularly shaped hole in its side (Figure 5).

Figure 5. A torn down queen cell.

Q: Why will a colony raise new queens?

A: There are three different circumstances that cause a colony to begin raising queen cells: swarming, supersedure and an emergency situation. It is important for beekeepers to be able to differentiate between these three circumstances.

1. **Swarming**

Swarming is how honey bee colonies proliferate without human intervention. However, managed colonies should be prevented from swarming. When a colony begins the process of swarming, the workers will start raising many queen cells. Just before the cells emerge, the original queen and the majority of the worker bee population will leave the hive together, in order to find a new location to settle as a separate colony. When the new queens finish developing, they will emerge and begin the fighting process. The survivor will mate and then take over the colony of remaining bees. The catalyst for swarming is large bee populations, which decrease the queen's pheromone levels within the hive. The queen's pheromones prevent swarming behaviour.

Swarming is most likely to occur in the late spring to early summer, when the worker population is reaching its peak. However, it can occur at any point in the season when resources are plentiful and conditions are cramped.. Some colonies are also more genetically prone to swarming than others.

When a colony is trying to swarm, you will see many large queen cells being raised. These cells are often located at the bottom or side edges of a brood frame, but they can be found anywhere in brood chamber (or in the supers, if there is no queen excluder). If swarm cells are found, ensure that the queen is still present. If she is still present, carefully inspect every frame in the brood chamber and tear down all swarm cells. If you can't find the queen, she has likely already departed with the swarm. In this case, the swarm cells should be left intact and the colony should be allowed to requeen itself. A new queen can be introduced later, if you wish to remain in control of the colony's genetics.

2. **Supersedure**

Supersedure refers to a situation where a colony determines the queen to be failing or unhealthy and raises new queens in an attempt to replace her. Supersedure can be caused by a failing queen, or a pest or disease problem, e.g. a high Varroa mite infestation. Typically, the old queen will be killed by the workers, just before the new queens emerge, allowing the new queen to take over.

Supersedure cells are typically smaller, and are often accompanied by an inconsistent brood pattern. Identifying supersedure cells is more reliable when based on context than the appearance or location of the cells, as it is possible to confuse swarm and supersedure cells if contextual clues are not considered.

Q: What is a failing queen?

A: As she gets older, the sperm stored in a queen's spermatheca can dwindle, and eventually run out altogether. This can happen earlier if she is not well-mated in the first place. A failing queen will lay an increasing number of unfertilized (drone) eggs, until she can't lay any fertilized (female) eggs at all. Without fertilized eggs, there will be no new worker bees being produced in the colony. Another type of queen failure occurs when the queen has been physically damaged, but remains alive. This typically occurs accidentally during a hive

inspection. It is recommended to cage your queen (or put the frame she's on in an empty nuc or hive box) in order to keep her safe during hive inspections.

3. Emergency

Emergency queen cells are raised when the queen dies suddenly. For example, if the queen is accidentally killed during a hive inspection. This is certainly an emergency, because without a queen to lay fertilized eggs, the colony can't raise a new queen. Without a queen, a colony will dwindle until it eventually dies. The workers can detect whether the queen is present by the pheromones she emits. Within hours of the queen's death/absence, the workers will begin emergency measures. If there are still fertilized eggs or young worker larvae present in the colony, the workers will start raising several of these as queens. Queens raised under emergency conditions are typically smaller and less successful than other queens, as they may have been raised from older larvae. Queens raised from older larvae will not have received as much royal jelly, limiting their development.

Emergency queen cells are typically small and stunted-looking in comparison to other queen cells (Figure 6). They can be found scattered across brood frames, and will sometimes be built into the frame, rather than suspended from it like a normal queen cup.

Figure 6. An emergency queen cell.

Q: When should I replace my queen?

A: Beekeepers can replace an existing queen if they are no longer laying well, or if they or exhibiting undesirable traits, eg. high defensive behaviour, susceptibility to pests and diseases, etc. Ontario is fortunate to have many local bee breeders who are selecting for locally adapted stock with desirable traits. Check out the Ontario Resistant Honey Bee Selection (ORHBS) program for a listing of breeders selecting for stock that is resistant to brood diseases, as well as other desirable traits. Note: it is best practice to replace queens earlier in the season, as replacing the queen in late summer/fall can put the colony at risk if she is not accepted.

Q: What is a laying worker?

A: Laying workers are a phenomenon that can occur when a colony is queenless, and there are no remaining female eggs/young larvae. Without the queen's pheromones to suppress them, workers can develop functioning ovaries, allowing them to lay eggs. However, workers cannot physically mate with drones. Therefore, laying workers can only lay unfertilized drone eggs. A colony with laying workers will eventually dwindle and die, as it cannot raise new workers or a new queen. Laying workers have evolved as a last-ditch effort to spread the colony's genes before it dies.

There are several distinctive signs of laying workers. You will only see drone brood being raised. This drone brood can sometimes even be found in supers, as laying workers can pass through queen excluders. You will also see multiple eggs laid haphazardly in cells, rather than one egg laid at the bottom of each cell (Figure 7). Eggs laid by laying workers are often found on the cell walls, as their abdomens are not large enough to extend to the bottom of the cell.

Figure 7. Eggs laid by laying workers.

Q: How do I deal with laying workers?

A: A colony with laying workers cannot survive long-term, as laying workers cannot produce female eggs. Simply introducing a new mated queen to a colony with laying workers will not be successful, as the laying workers are likely to reject the new queen. Depending on the severity of the situation, it is possible to introduce a nuc to a colony with laying workers. However, if the colony has been queenless for a long time and there are many laying workers present, this strategy is less likely to work. Before introducing the nuc, shake the workers off of the brood frames in front of the hive - sometimes the laying workers will be prevented from re-entering the hive.

In severe cases, or if you would rather not risk a new queen, the only thing to do is to shake out the colony. Shake all the bees off of frames on a sunny day. Avoid shaking frames directly in front of queenright hives. The regular workers will typically be able to join other colonies, while the laying workers will be barred from entering a queenright hive.

Q: What is the queen colour coding system?

A: There is an international colour coding system that helps beekeepers keep track of their queens age and lineage. Queens are marked based on the year they were raised. Marking your queens is beneficial not only because it helps you keep track of the age of your queen, but because it makes her easier to find during inspections. It is also useful to know if the colony has requeened itself.

Colour coding system:

Year ending in 1 or 6 = White
Year ending in 2 or 7 = Yellow
Year ending in 3 or 8 = Red
Year ending in 4 or 9 = Green
Year ending in 5 or 0 = Blue

For example, a queen raised in 2023 will be marked red. There is a mnemonic to help you remember: Will You Raise Good Bees?