Naturally Built Queen Cells: An Introduction to their Biology & Use in Honey Bee Management

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Naturally occurring, well-constructed queen cells from good bee breeding stock can be a good source of new queens in a beekeeping operation. To use these queen cells, the beekeeper should know some basic queen cell biology and possess the skills to move queen cells between colonies. More specifically, the beekeeper must learn how to judge good queen cells from inferior ones, how to remove queen cells from the comb, how to transport queen cells between apiaries, how to reattach queen cells to the comb, and how to troubleshoot with queen cells.

The description of handling queen cells is not very common in the beekeeping literature; I learned mainly through trial and error. My skills in handling queen cells began when I started beekeeping in the 4th grade, and it was a natural consequence of my fascination with queen cells. Typically, I would cut a queen cell from one comb and reattach the cell to another comb in a queenless observation hive and observe the bees' reaction. Sometimes, I would have three observation hives in my bedroom with each one undergoing some kind of "queen cell experiment." I had a very understanding mother. If the bees got loose in the bedroom, she would stuff a towel under the bedroom door to prevent the bees from going into the other parts of the house, and wait for me to get home from school. Without realizing it at the time, I was developing the skills necessary to handle queen cells. Later in my beekeeping life, these skills would become very beneficial, not only in money saved from queen replacement costs, but also in time and travel. For example, if I find a queenless (and broodless) colony in an outyard, sometimes I can find another nearby colony with queen cells (maybe from a colony superseding its queen). One of these queen cells can be moved to the queenless colony. Transferring the queen cell saves the queenless colony time in replacing its queen if the alternative was giving the queenless colony young worker brood from another colony. Using a queen cell could also save me a return trip to the outyard if the alternative was using an extra queen from my homeyard or purchasing a new queen. Thus, being able to use naturally built queen cells gives the beekeeper more options in solving bee-management problems.

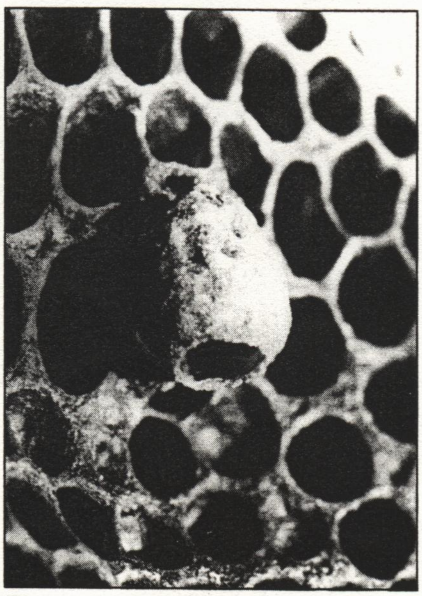

Figure 1 - A natural queen cell cup. A queen cell cup is the precursor of a queen cell. Supersedure and swarm cells are typically begun from queen cell cups.

Before describing how to judge and move queen cells, let's briefly review some basic queen cell biology and terminology. Queen cells occur naturally under three conditions: when bees prepare to swarm, to supersede a failing queen, or from emergency queen loss. Queen cells reared under these three conditions are referred to, respectively, as swarm cells, supersedure cells, and emergency queen cells. When swarming, bees usually build many swarm cells near the edge of the brood comb. In contrast, bees superseding their queen typically build a few supersedure cells in the central region of the comb. Swarm or supersedure cells usually begin from queen cell cups (see Fig. 1). A queen cell cup is a precursor of a queen cell, consisting only of the cell's base and about a third of the cell's wall. Queen cell cups are usually present in the colony most of the time; however, they are generally empty except during swarming and supersedure. When containing a fast growing queen larva, the bees enlarge and extend the queen cell cup into a queen cell. In contrast, if the queen dies suddenly, the bees are usually forced to begin the emergency queen cell by enlarging a worker cell containing a young larva.

From egg to adult, the queen develops in about 16 days. Although the larva is female, the production of an adult queen or worker is determined by the larva's diet. The diet for queen formation is commonly called royal jelly and differs from the larval diet of the worker bee larvae. When the nurse bees finish provisioning the queen cell with royal jelly, the bees build a wax cap across the cell's opening. Now the cell is referred to as a "sealed" queen cell. For about a day after her cell is sealed, the queen larva continues to feed on this stored food. In contrast, the worker larva has little or no food left at the time her cell is sealed. Before transforming to a pupa, the queen larva spins a partial cocoon. The cocoon extends across the cell's cap and up the sides, but not across the base of the cell. Typically, the bees will remove some of the wax cap and expose the end of the cocoon prior to the queen's emergence (see Fig. 2). The presence of an exposed cocoon can be used to distinguish a queen cell that has been sealed for some time from a newly sealed cell. Sometimes beekeepers refer to the exposed cocoon as a "bald spot" on the end of the queen cell. When the queen is almost ready to emerge from her cell, the queen cell is referred to as a "ripe" queen cell.

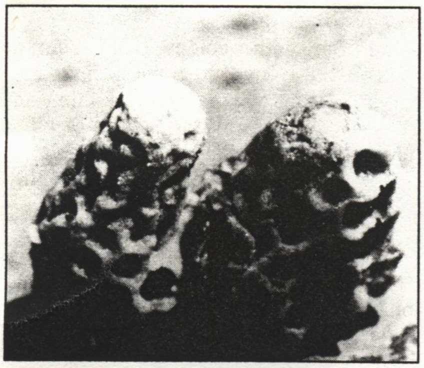

Figure 2 - The exposed cocoon of the queen cell. As the sealed queen cell ages, the bees remove some of the wax capping and expose the queen's cocoon. The exposed cocoon is seen on the end of the queen cell on the right. For comparison, the queen cell on the left is newly sealed and has the initial heavy wax cap.

Judging Queen Cells

Independent of whether the queen cells were built in response to swarming, supersedure, or emergency queen loss, only the best cells should be used for producing new queens. The egg laying capacity of these new queen bees will vary, in part, because of differences in their developmental environments. For example, queen larvae that received generous amounts of royal jelly grow larger, and as queens, are expected to have a larger egg laying capacity. Some of the differences in the queen's developmental environment are reflected in the size and the appearance of her queen cell. Therefore, it is important to be able to distinguish good queen cells from inferior queen cells, because we expect the better queens to come from well-constructed queen cells.

Queen cells vary in size, and in judging queen cells, size is very important. Larger queen cells tend to indicate a better developmental environment. Therefore, larger queen cells are better than smaller ones. For example, Figure 3 shows a size comparison between a small queen cell reared under emergency queen loss conditions and a large queen cell reared under supersedure conditions. If the smaller queen cell is opened and the pupa is removed, very often, little or no excess royal jelly remains in the cell. This lack of excess food can indicate that the former larva may not have been properly fed and may result in a poor queen. In contrast, the larger queen cells, that typically result from swarming or supersedure, contain excess royal jelly i.e., more royal jelly than the larvae could consume. Therefore, these larvae were probably fed properly. By the time the queens emerge, the previously glistening white royal jelly will appear as a reddish-brown substance at the base of the cell.

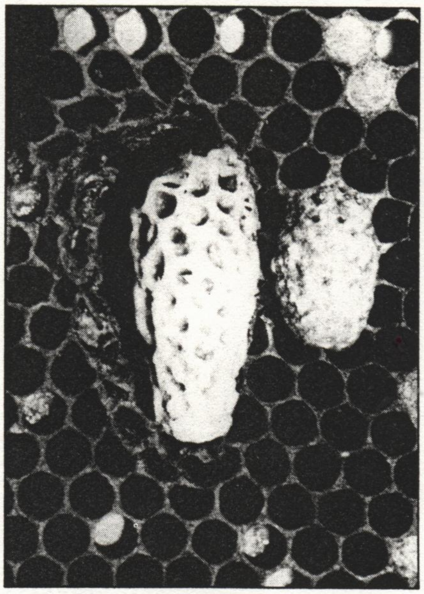

Figure 3 - Judging queen cells by comparing their size and amount of sculpturing. Superior queen cells are larger and better formed with extensive sculpturing. Superior queen cells usually indicate a better developmental environment and are expected to produce better queens.

The amount of sculpturing on the queen cell can also indicate its quality. This sculpturing is seen as a series of small pits on the sides and base of the queen cell. Inferior queen cells tend to be smoother because they lack extensive sculpturing. Referring to Figure 3 again, notice that the larger queen cell is more sculptured than the smaller queen cell. The lack of sculpturing indicates the queen cell received less attention during its construction, and hence its larva, received less attention during its development. Typically, queen cell size and the amount of sculpturing occur together, such that larger cells have more sculpturing.

Moving Queen Cells Between Colonies

Although a frame with the naturally built queen cells can be transferred between colonies, usually it is more efficient to cut these cells from the combs of the donor colonies and attach them to the combs of the recipient colonies. For example, if I have three queenless colonies, I can requeen them with three queen cells. Rarely will these queen cells be found as one queen cell per frame. If I find three queen cells on one frame, these queen cells are used most efficiently by removing them from the comb of the donor colony and giving one queen cell to each of the queenless colonies.

In addition, sometimes the queen cells must be transported to recipient colonies in another apiary. I move only sealed queen cells between colonies, making sure the recipient colony has been queenless for about 24 hours. Because the bees have finished provisioning a sealed queen cell with royal jelly, moving the cell does not interrupt the food provisioning process. Unsealed queen cells should not be moved because the recipient colony has usually been weakened by queen loss, etc. and may not fmish provisioning the queen cell with a generous amount of royal jelly. I use my pocket knife to cut the queen cell from the comb, being careful not to expose the developing queen or denting the cell (see Fig. 4). Queen cells constructed from queen

Figure 4 - Removing the queen cell from the comb. I gently remove the queen cell by cutting it from the comb with my pocket knife.

cell cups are usually easier to remove from the comb than are emergence queen cells. Because emergency queen cells are constructed from worker cells, the cavity of the cell extends to the midrib of the brood comb (i.e., to the foundation). In order to separate the emergency queen cell from the comb without exposing the developing queen, you must cut out a plug of the underlying comb. This process is not only messy, but can be quite difficult if one encounters reinforcing wires or plastic foundation. As a result, not only are emergency queen cells usually of poorer quality, they are also harder to remove from the comb. Therefore, I rarely use emergency queen cells in producing new queens. In contrast, the cavity of queen cells constructed from queen cell cups only extends to the former queen cell cup, which is not very deep in the brood comb. Because in many cases, these queen cells only extend a little into the face of the brood comb, they are easy to remove. Thus, swarm and supersedure queen cells are usually well constructed and easily removed from the brood comb as compared to emergency queen cells.

After removal from the donor colony, the queen cell must be attached to a brood comb in the recipient colony. First, select an area of comb a little larger than the cell in a location with much bee activity. Remember the queen cell must be kept at brood rearing temperature for proper completion of the queen's development. Typically, the central area of the brood comb is adequate. Now make a depression in the comb a little larger than the queen cell by squashing some of the brood cells. (See Fig. 5) Try to squash empty brood cells because the contents of these squashed cells can interfere with the wax to wax cohesion between the brood comb and queen cell. Sometimes empty brood cells are hard to find in the central area of a crowded brood comb, and it may be tempting to place the queen cell near the edge of the comb, where empty cells are more common. However, if the ambient temperature drops, for example during a chilly spring night, the cluster can contract away from the queen cell, and the developing queen could die from exposure.

Next, with its capped end down, gently press the queen cell into the depression, being careful not to distort the shape of the cell. (See Fig. 5) When the cell is in place, be sure nothing will obstruct the queen's emergence from the cell. If the dented area is wet from the contents of the squashed brood cells, the attachment between the queen cell and brood comb can be strengthened by adding a little extra wax (i.e., pieces of smashed burr comb) around the base of the cell. If the queen cell extends too far above the face of the comb, the bees may attach the cell to the adjacent comb. When the queen cell is attached to both combs, it may be torn apart if the combs are examined before the queen

Figure 5 - Attaching the queen cell to the comb. On the left is an area of squashed brood cells forming a depression. The queen cell is gently pressed into this depression as seen on the right.

emerges. When attached properly, the queen cell will remain in place while the bees repair the damaged comb, and in the process, attach the cell more firmly to the comb. With a little practice, attaching a queen cell to a comb will become quite easy.

After removal from the donor colonies, some queen cells must be transported to another apiary. During transport, queen cells can be damaged by temperature fluctuations and physical shocks. Therefore queen cells should be kept out of the hive no longer than necessary and handled gently. Newly sealed queen cells seem to be more vulnerable to temperature fluctuations and physical shocks than do ripe queen cells. When the bees have partially exposed the queen's cocoon (as was shown in Fig. 2), I feel it is relatively safe to transport the cell. Sometimes I carry my queen cells in a small specially constructed wooden box. The bottom of the box has a thick bottom with holes cut in it to receive the queen cells. I have also briefly carried queen cells in my shirt pocket. Occasionally, a queen will emerge in my pocket and crawl up on my shoulder.

To gain skill in moving queen cells between colonies, practice on extra queen cells you find in the apiary. For example, instead of just smashing a colony's swarm cells, try cutting them from the comb without damaging them.

Troubleshooting with Queen Cells

When confronted with colonies that show indications of recent queen rearing activity, beekeepers with the ability to recognize and interpret the meaning of recently vacated or partially dismantled queen cells are more likely to correctly determine the needs of those colonies. When troubleshooting with queen cells, the beekeeper needs to act like a detective. The beekeeper/detective has to recognize clues (for example, old queen cells, etc.) which function as evidence for various alternatives (for example, whether the colony has a queen or not). Let's begin by looking at some of the clues and then see how these clues are used as evidence to determine what happened in the colony. For example, Figure 6 shows three queen cells where the queens have emerged. By the time the queen is ready to emerge, the bees have removed most of the wax from the cap of the queen cell, leaving only the

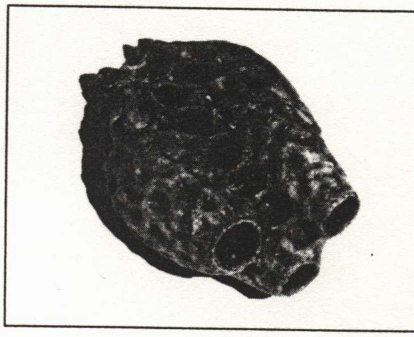

Figure 6 - Queen cells where the queens have emerged. Queen cells with their caps opened or removed indicate their queens have emerged.

queen's cocoon. To emerge from her queen cell, the queen cuts through the remaining cocoon in a manner similar to opening a can with a can-opener (from the inside out). As the queen chews through her cocoon she presses against the cap until it pops open. Eventually, the bees remove the cap and begin to dismantle the cell. An important contrast to a queen cell where the queen has emerged is a queen cell that has been destroyed by a virgin queen. Virgin queens destroy queen cells unless the worker bees intervene. Holes in the side of a queen cell typically indicate the presence of a virgin queen (See Fig. 7). Other possibilities include queen cell destruction by the mother queen or the worker bees, or that the cell was dismantled because the developing queen has died from other causes. Virgin queens are so efficient at finding and destroying queen cells that when it appears they have missed a cell (it looks normal), it is very probable that the cell is empty or contains a queen that died from other causes. An empty queen cell can occur when the cap closes back on the cell after the queen emerges. Empty queen cells can look normal because the bees will sometimes reseal the cap to the queen cell, making it appear that the queen has not yet emerged.

Figure 7 - Queen cells destroyed by a virgin queen. Queen cells with holes in their sides have been destroyed typically by a rival queen.

I always suspect that something is wrong when I find an apparently normal looking queen cell among cells that have been destroyed by a virgin queen.

Sometimes the worker bees are slow to completely dismantle vacated queen cells and these queen cell remnants indicate a past queen rearing episode (See Fig. 8). Queen cell remnants tend to remain longer in weaker colonies because fewer worker bees are available to dismantle the queen cells. Sometimes I see these remnant queen cells in my hives that have died over the winter. The presence of these cells is a clue indicating the colony may have failed to replace its laying queen the previous fall, and the worker bee population slowly dwindled away over the winter. Notice that by recognizing the presence and meaning of these remnant queen cells, the beekeeper has developed a better understanding of why his or her colonies died over the winter. In addition, I have seen cases where a beekeeper attempted to replace a queen in an apparently queenless colony. The colony in question was determined to be queenless because of the absence of brood. Finding no queen cells in the colony, the beekeeper attempted to introduce a previously purchased queen. The queen introduction failed (in one case several queen introductions failed, which given the price of queen bees, obviously gets expensive). Upon closer inspection, remnant queen cells were found indicating the colony had reared a virgin queen. The death of the introduced queen in this case was probably due to the presence of the virgin queen and it would be easier to let her become the mother queen of the colony. Even if no evidence of recent queen rearing was found in this case, we would still suspect the presence of a virgin queen. However, finding evidence for recent queen rearing by way of remnant queen cells supports the possibility of the colony having a virgin queen. Notice how this beekeeping/detective work progresses; by looking carefully for the clues and interpreting these clues as evidence for a particular solution.

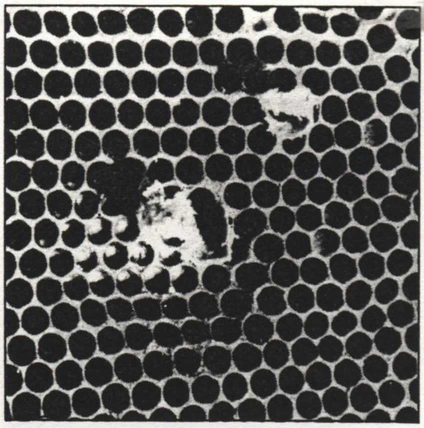

Figure 8 - Queen cell remnants. Once the queen cell is vacant, the bees begin to dismantle the cell. If enough of the queen cell remains, the beekeeper can sometimes tell whether the queen hatched or was destroyed. These queen cell remnants probably had hatching queens because the capping appears to have been removed in a manner consistent with an emerging queen. These queen cell remnants were from one of my colonies that died during the winter of 1995. Although a queen appears to have hatched, apparently she failed to mate (probably in late summer to early fall) and the colony dwindled away during the winter. By knowing about queen cell remnants, the beekeeper can sometimes tell when winter colony mortality resulted from queenlessness.

As another example, consider this situation that confronted me a few weeks ago. I was introducing three very special adult queens. These queens had been artificially inseminated for use in some of my genetic research. I could not afford to lose even one. As "luck" would have it, during the introduction process I had to leave for a mathematics conference for about a week. Given my absence, I decided not to release these queens until I returned. By that time I expected to find some sealed queen cells in the three colonies because initially these special queens would be foreign to their new colonies. Upon my return I would remove these queen cells before they hatched. As expected, two of the colonies had only sealed queen cells. In the third colony, I found a queen cell with a hole in its side as seen in Figure 7. At this point, I am only suspicious that a virgin queen has emerged because some queens die before completing their development and maybe the worker bees made the hole in the queen cell. The next comb had two more queen cells with holes in their sides. Now the probability of three neighboring queen cells with queens dying from natural causes is very unlikely. Therefore, it is much more probable that a queen cell in this colony hatched a little early. Another comb had an undamaged sealed queen cell with a live queen pupa. This undamaged queen cell - by itself - would tend to indicate no virgin queen was present; however, taken with the other evidence, it was very possible that the early emerged virgin queen was still in the process of destroying the rival queens in their cells. Another comb had a queen cell on it where the queen had emerged (similar to Figure 6).

Now given all the evidence, I am virtually certain that a virgin queen is in the colony and I begin a careful and methodical search for her. Virgin queens can be difficult to find in a colony because they are smaller than laying queens. Also virgin queens are easily disturbed and try to hide among the other bees. In addition, virgin queens can be found anywhere within the hive, unlike laying queens which are normally found in the brood nest. After a bit of searching, I found a downy white virgin queen bee. Her downy white appearance indicated her recent emergence, and she must have been in the process of destroying queen cells when I opened the hive. Had I not removed her, she or the bees may have killed the special queen that I was introducing to the colony. By carefully observing the queen cell clues and properly interrupting this evidence, I was able to save my special queen.

With a little practice, moving queen cells between colonies and queen cell detective work becomes easier and definitely makes for more enjoyable and trouble-free beekeeping.

Acknowledgments

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Requeening

It can easily be done in the fall when queen prices are cheaper, nectar is still available and the resulting larger proportion of young bees will help colony overwintering.

The useful life of the queen bee varies considerably. Many times colonies in the apiary will replace their queens even though the beekeeper may consider that the same queens are present in those colonies continuously. Replacement of a queen by the bees is called supersedure. Those who have marked queens so that their identity is always certain have found that supersedure will vary from one to several times a year or that some queens may continue in the colony for several years without being replaced by the bees.

Probably the majority of beekeepers depend entirely on the bees for queen replacement and if colonies become queenless in the process through failure of the bees in supplying their own new queen, such colonies will be united with others and the equipment refilled by division or the purchase of new bees.

However, in good beekeeping practice, requeening should be to a large extent under the control of the beekeeper. While it is true that many of his colonies will supersede successfully, it is also true that many will fail. He should learn to judge queen bees from the standpoint of their physical appearance and their work, and replace queens that are not giving the best results.

A good queen usually has a physical conformity to correspond with her ability in egg laying. The good queen will never look harried, worn, with frayed wings, or slender body due to lessening powers, but she will have a long, heavy abdomen which is neither blunt nor pointed, and yet well rounded, somewhat slender toward the end indicating well developed ovaries with numerous egg tubules—all at maximum efficiency.

Such a queen is capable of laying from 1500 to 2,000 eggs a day at the height of her brood rearing and, with proper environment and management, will produce a large colony of bees to produce a correspondingly large crop of honey.

A queen that has a blunt abdomen, somewhat shortened, seldom has long laying power and soon exhausts her fertility. Queens that have a rat-tail shape, rapidly slendering to an overpointed abdomen frequently display uneven brood and erratic egg laying.

In apiary practice it is usually best, however, to judge the queen by her brood area. Young queens lay vigorously and regularly and their brood is in even masses with very few cells skipped. Of course, as pollen is gathered or as nectar comes in, sometimes cells are occupied by pollen and nectar, and the queen has to miss them

There are three periods when colonies may be requeened to advantage: In early spring during fruit bloom or dandelion bloom or some similar period when there is available nectar and colonies have not yet begun to expand into full brood rearing; during the honeyflow when it is advantageous to keep up the production of the colony with the work of a new vigorous queen; and in the fall period when nectar is available, and the laying of the new queen will give the colony a large addition of young bees for wintering.

to find room to lay, so gradually as the colony reaches its highest point in brood rearing, the brood becomes somewhat scattered. However, early in the season, queens should lay regularly and only have to miss such cells as may be filled with sealed honey and pollen.

When the laying is irregular and the cells are left open in which eggs could have been placed and the queen begins to wander around the comb between her laying periods, it is likely that the queen is losing her vigor. During a dearth of nectar with nothing available in the field, usually queens will not lay freely, and of course, this must be considered when judging the work of any queen.

As the brood develops, all the given area around about the center must develop at an equal rate. If some cells have large larvae and others beside them have small ones, there is something wrong with the performance of the queen.

It used to be advised to replace queens each year or certainly every two years or by some other periodical calculation. It is now considered the best practice to requeen whenever colonies show that they can benefit by the change. However, there are certain times when requeening is more easy or when queens are more readily acceptable than at other times.

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The importance of balance should be remembered when trying to requeen bees. Queens which are received through the mail are quite easily introduced and readily accepted in the spring nectar flow, and it is comparatively easy then to find the queens that are present in the colony because the brood area is relatively small. There is not a great force of bees present so that it is possible to hunt out the old queen with very little trouble. The queen purchased from the South or elsewhere may be then introduced with the mailing cage method.

In the fall period, this same practice may be followed during a time when the colony is declining and reducing the brood