WHO IS THE QUEEN BEE?

Alex Tuchman

INTRODUCTION

Beekeeping today presents us with no small number of challenges. Indeed, the life of the honeybee and the profession of beekeeping are in serious crisis—most people are aware of this. We have a great responsibility to leave no stone unturned as we search for the underlying causes of the plight of the honeybee. One such underlying cause is hiding in plain sight, namely, artificial queen rearing. To explain this in a way that engenders understanding and can bring forth appropriate solutions, we shall start by asking the question: *who is the queen bee?*

THE CONCEPTION OF THE THREE CASTES OF HONEYBEES

In the dark fragrant warmth of the hive center, the queen places an egg into a wax cell, which has been created by the worker bees. This union of egg and wax cell is the creative foundation for all three castes of honeybees to emerge: queens, workers, and drones. As our goal in this article is to understand the inner nature of the queen, we will first place her in juxtaposition to the other two castes to gain a holistic concept of how she comes into being. In other words, how does each caste come about, and what are the determining factors that make a queen?

Honeybees develop from egg to adult in a process called *complete metamorphosis*. This means that honeybees have four distinct stages of development: [1] egg, [2]larva, [3]pupa, and [4]adult. Butterflies undergo complete metamorphosis as well, but do so in the open air: the adult female places her egg on a leaf, the egg becomes a caterpillar (larval stage), the caterpillar spins a cocoon and chrysalis around itself (pupal stage), and finally hatches into an adult butterfly. Each butterfly goes through this development alone and fully exposed to the elements. Conversely, the honeybees protect each stage of metamorphosis within the innermost depths of their colony, where a temperature of ~95° F is necessary for a healthy development[1].

Out of their own bodies the workers create *wax platelets* which they then shape the wax with their mandibles into the required cell type. The queen creates eggs in her ovaries, which pass one by one into her vaginal canal. She will either releases sperm into her vaginal canal to fertilize the egg (to create a female worker or a queen), or leaves the egg unfertilized (to create a male drone). The worker and the queen eggs will be fertilized with sperm that the queen carries in a special organ called the *spermatheca*. When the queen places a *fertilized egg* into a horizontal-hexagonal wax cell, then a worker arises. When the queen places an *unfertilized egg* into a horizontal-hexagonal wax cell, then a drone arises. With the worker and the drone, the fertilization of the egg is the determining factor. But what differentiates the worker and the queen, who both become females born from a fertilized egg? The fertilized egg placed into a *horizontal-hexagonal* cell becomes a worker, as we said above. But the fertilized egg placed into a *vertical-round* cell becomes a queen. Therefore, the primary determining factor that allows a queen to develop is the form, shape, and orientation of the wax cell into which the fertilized egg is placed.

Thus, we see the effect that both genetic material and architectural form have on the differentiation of life. With sperm and egg vs. egg alone, we find the essential difference between female and male. And with horizontal-hexagonal vs. vertical-round, we find the essential difference between worker and queen. In a horizontal-hexagonal cell, the worker's sexual organs become atrophied but she develops the capacity to serve her fellow honeybees all the more through her development in this six-sided and horizontal form. The special development of the worker enables her to create royal jelly, sweat wax, generate warmth, transform nectar into honey, transform pollen into bee bread, guard and keep the nest, gather provisions, pollinate flowers, and more. In a vertical-round cell, the queen develops the capacity to produce vast amounts of queen substance[2] and pheromones which engender unity in the worker bees, and above all, she develops an incredibly active metabolic system

and two large ovaries in her abdomen which give her the capacity to lay eggs.

Through our thought process above, we have already understood how a queen comes about through the development that nature wisely guides. This point must be made, because it is commonly overlooked and rarely taken seriously how dramatically **form** affects certain powers, abilities, and processes of development.

At this point, there is a great confusion in the scientific world because another factor comes into play, namely, the effect of the diet that is fed to the larva and the consequences that this has on the further course of its development from pupa to adult bee. We will soon see how those who artificially rear queens have a great stake in emphasizing as they do that diet alone is what makes a queen into a queen.

THE EGG, LARVAL, PUPAL, AND ADULT STAGES OF DEVELOPMENT

The queen has the capacity to lay over 1500 eggs per day. To do so, she must consume and metabolize more than her own body weight in food each day! Every single egg is nourished by a yolk that allows the egg to transform over the course of three days into a larva. For all three castes, the egg stage lasts three days. The health of the eggs, and consequently the hive as a whole, greatly depends on the queens' metabolism and the quality and quantity of nourishment she receives.

The egg undergoes a metamorphosis to the larval stage, which for all three castes extends roughly 6 days. Here we see differentiation in how each caste is fed to allow each larva to promote the divergence among castes. The larvae are meticulously cared for, with each one (of which there may be thousands) being visited, fed, warmed, turned, and cleaned every three minutes on average. This incredible attention to rearing young is rarely found in the insect world; it is much more common among mammals. In the larval stage, the organ-system known as the *fat body* is built up, upon which the internal organs will develop during the pupal stage.

Typically, the worker larvae and drone larvae are both fed royal jelly for the first three days of development before they are graduated to a diet of nectar and bee bread (fermented pollen) for the second half of their larval stage. The queen larva, however, is fed purely royal jelly for the 6-day duration of her larval stage which supports the development of her ovaries to come into full expression when her internal organs are formed during the pupal stage. This diet also accelerates her overall growth and development, requiring only 7 days as a pupa before hatching into an adult queen bee. From egg to adult, the queen requires only 16 days. This is compared with the worker who requires 21 days, and the drone who requires 24 days.

Now we have described how the three different castes of bees come about. As long as the hive has a healthy and fertile queen to lay eggs, the appropriate number of workers and drones will be created. In an average hive at the height of the season this amounts to about 45,000 workers, and 5,000 drones. It is a normal process for workers and drones to die and be replaced throughout the season. But what about the replacement of the queen?

PART 2

How does it happen that a colony goes about replacing their queen? If the bees sense that the queen is getting old and/or not performing well, they will simply build new vertical-round queen cells, in which the queen will place eggs, and then she will be replaced when a new queen emerges. But what if she dies by some strange accident and leaves no other queen waiting in the wings? For this emergency situation, which would otherwise mean the sure death of the colony as a whole, the bees have a miraculous solution. They choose several young worker larvae, and modify their horizontal-hexagonal cells into vertical-round queen cells. Once the form of the cell been

changed, they simply feed these larvae as if they were queens in the way described above and new queens will result. These are called *emergency queens*. The bees have this ingenious capacity to take a larva that was originally intended to be a worker, put her into the correct form and position for her larval and pupal stages of metamorphosis, build up her fat body with reserves of royal jelly in the larval stage, and allow her to become an emergency queen.

There is something different about this queen, however. She has been in the wrong position and form during the first 4 days of her development. Thus, we make the distinction between the *emergency queen* that spends a quarter of her development in the wrong form and position for a queen, and the *true queen* that has had a full development from the day her egg was placed into the vertical-round cell.

It is evident from observation that the bees sense this emergency queen will need to be replaced. Indeed, hives often replace these emergency queens with true queens within the first season--sometimes even within the first month! The bees themselves do not create a queen in this way unless it is an emergency situation. Scientifically, we can demonstrate that the ovaries of an emergency queen are significantly smaller than those of a true queen.[3] In addition, the life expectancy of an emergency queen is only 1-2 years,[4] whereas a true queens' life expectancy is 3-5 years. That being said, forming an emergency queen is an incredible feat for a hive that would have otherwise been doomed to die. The emergency queen will fill the role as a worthy servant within the hive until she is replaced by the normal process.

Now we have described the way that a colony creates workers, drones, queens, and emergency queens.[5]

THE EMERGENCY QUEEN AND ARTIFICIAL QUEEN REARING

Almost all that we know of these incredible life processes within the honeybee colony were discovered after the invention of the Langstroth hive in 1850 when the removable frame was introduced into beekeeping and the inner world of the honeybee hive was revealed right before our eyes. In fact, before 1850, the prevailing understanding in the West was that there was a king in charge of and guiding the behavior of a hive! Even Aristotle was humbled in that respect.

But the most important discovery for the next and the prevailing era of beekeeping was the discovery of the emergency queen, which sparked great curiosity in many scientists and beekeepers including Gilbert M. Doolittle. In 1890, this American beekeeper published *Scientific Queen Rearing*, a book that outlines the method that beekeepers still use today to artificially produce emergency queens.

The Doolittle method, as it is commonly known, utilizes a small spoon which scoops out newly hatched worker larvae and places ~40 of them into a plastic cups. The special frames of plastic cups are then placed into a queen-less hive, where the workers feed these larvae royal jelly and they become emergency queens. These queens are then inseminated (either naturally or artificially), and shipped in little cages around the country to beekeepers who methodically kill the year-old queen that they bought last year and replace it with the new queen that they have purchased. Artificial queen rearing has become a big business, and has virtually eliminated true queens from modern beekeeping. Almost every nucleus colony or package of bees on the market today is equipped with an emergency queen that has been produced by this or a similar method of queen rearing. The means of production have been commodified, with the benefits of promoting youthful vigor, more easily controlling genetics and breeding, significantly curbing natural hive reproduction (swarming), and most importantly, producing more honey for the market.

Beekeepers know, consciously or unconsciously, that a foreign queen will not be readily accepted by any hive, even if the hive is doomed to die because it does not have a queen. Great precautions must be taken to avoid the inevitable

response that drives the hive to immediately remove or kill the foreign queen. Like a healthy immune system, the hive recognizes that a foreign queen has entered, and wastes no time expelling her. Artificial queens are introduced to hives in a small cage whose entrance has been plugged with sugar candy (which takes ~3 days to gnaw through) and accompanied by several bees who travel with the emergency queen to protect and feed her inside the cage. The bees are then forced to accept the foreign queen into their organism as the only chance for a future, and are given three days to get used to her before the sugar candy is gnawed-through and the queen is free to exit the cage.

Compare this to the natural emergency situation where the hive produces the emergency queen from within its own organism. The emergency queen that the hive chose to make has a genetic harmony with the rest of the hive. It is not a foreign invader at all, but truly an inner metamorphosis of the same organism.

THE EFFECTS OF ARTIFICIAL QUEEN REARING

The modern beekeeper has taken the emergency adaptation process of the honeybee hive and made it into the conventional commercial practice. What are the consequences of the last 100+ years of scientific queen rearing?

The state of our queens today is in crisis. The health and vitality of queens and their hives has rapidly declined. The *Journal of Apicultural Research* reported in May of 2016 that the average life expectancy of an artificial queen in the United States is 9 months,[6] as opposed to 3-5 years, which is the natural life-span. This seems to be the hallmark of a system based on emergency queens. There has been a significant loss in colony health and inner harmony which is demonstrated by the huge failure rate of packaged bees and their emergency queens. The observant beekeeper senses the innate impulse of the workers to replace the artificial emergency queens. The presence of a non-genetically related emergency queen causes disruption to both the harmony and cooperative ability of the colony, having a cascading effect on the health and fitness of the whole organism. Parasites, disease, colony collapse, and the common illness of *supersedure queens* (described below) are typical outcomes.

Ironically, much of the scientific research being conducted to help find the cure of the honeybee plight focuses on the symptoms of a weakened colony (e.g. mites, viruses, bacteria, disease, etc.) rather than the direct cause of the weakened colony. The industry, commercial beekeepers, and commercial scientists are diverting the public's attention toward treating the symptoms rather than the root cause of the problem. Especially harmful is the claim of ignorance, that "we don't know what is killing the bees". This rhetoric deflects the responsibility away from commercial beekeeping practices altogether, allowing artificial queen rearing to continue unquestioned.

PART 3

AN INTRODUCTION TO THE BEE LECTURES OF 1923

It is very interesting to note the special relationship that biodynamic beekeepers have to artificial queen rearing, as it has been discussed in those circles of beekeepers since Rudolf Steiner gave his lecture cycle entitled *Bees* in 1923. Steiner's lectures were given in response to questions from an audience of construction workers who were working on building the Goetheanum in Dornach, Switzerland at that time. Several of the workers were also beekeepers, including Mr. Mueller, who was a professional beekeeper and who also gave a few lectures parallel to Steiner about modern beekeeping methods. In these bee lectures, Steiner spoke from many different points of view about the nature of the honeybees and beekeeping, addressing the issue of artificial queen rearing, which had just become popular among beekeepers at that time in Europe. He said to the workers:

WHO IS THE QUEEN BEE?
Alex Tuchman

"Gentlemen, you must not believe that I can't understand, even from the standpoint of non-anthroposophic science, that, beginning with the very first steps, much can be said for artificially breeding bees, because it does simplify quite a few things. But the strong bonding of a bee generation, a bee family, will be detrimentally affected over the longer period. In certain respects you will be able to only praise artificial breeding, if all necessary precautions are taken, as Mr. Muller described to us. But we'll have to wait and see how things will look after fifty to eighty years. Certain forces that have operated organically in the beehive until now will become mechanized, will in themselves be mechanically carried out. It won't be possible to establish the intimate relationship between the queen bee you have purchased and the worker bees the way it would arise all by itself in nature. But at the beginning, the effects of this are not apparent."(21)

Steiner predicted with accuracy where this whole process was going, and the precision and details of his insights are jolting. He provided a precocious warning about changing the natural course of queen development from the beginning of the era of artificial queen rearing. Steiner even pointed to the relationship breaking down between the workers and the queen, which is playing out 100 years later with the rampant occurrence of supersedure queens in conventional beekeeping. Supersedure occurs when there is a breakdown in the communication between the workers and the introduced artificial queen. The workers want to establish a new, true queen so they build vertical-round wax cells for the artificial queen to lay into, but she does not take the cue. The workers are then forced to supersede her, that is, they create an emergency queen from a worker larva in order to replace the existing artificial queen to whom they cannot form the proper bond. This dysfunctional breakdown must be seen as an illness of the colony. The natural marriage between egg and wax cell that is the basis of the hives' life has been disrupted.

BASIC AND PRACTICAL IDEAS FOR WORKING WITH NATURAL QUEENS

If a queen is too old to carry out her productive work, or failing to lay eggs, or dying, the bees themselves have two options. First, the workers can create a queen cell (or multiple cells) in which the old queen will place an egg. This method of natural replacement will occur every 3-5 years in a healthy hive. Second, if the queen has died suddenly, the workers can create an emergency queen who will serve in the interim until the hive replaces the emergency queen with a true queen. In a healthy apiary, the second option is a special situation and quite uncommon.

Occassionally the beekeeper observes that a hive is queen-less and egg-less. This is because for whatever reason, the bees were not able to replace the queen naturally. Again, in a healthy apiary this is quite uncommon. In such a case, comb with eggs can be taken from another strong hive in the apiary and placed into the queen-less hive. In this way, the workers will create an emergency queen from a newly hatched egg that came from another hive. The bees will almost always take this option if they are queen-less. Another option is possible only seasonally. During swarming season (April-June), hives create many new queens before they swarm. If a hive becomes queen-less during the time period when these new queens are being raised within the apiary, then this abundance of true queens can be of great benefit to the queen-less hives, or to neighboring beekeepers who might need a queen. This natural abundance of queens developing in their *swarm cells*[7] can be carefully removed and placed into queen-less hives so that all colonies can have healthy and strong true queens for the rest of the year. Small mating nucs can also be constructed to preserve this valuable resource of surplus queens through the Fall.

Of course, the manipulations of the beekeeper are only second best to what the bees can create for themselves within their own hive. You can

gather from the beekeeping methods presented above that biodynamic beekeepers will sometimes take the measure of introducing a queen or eggs from another hive in order to save a queen-less hive. It is in these uncommon cases when a hive would otherwise be unable to help itself that one can choose to step in and give a hive the queen that is necessary for its survival.

The main challenge for beekeepers in these critical situations is to find what is appropriate and necessary for the bees, and to intervene accordingly. We will each have to come to our own conclusion on this matter, and we might even develop personal relationships with each hive so we rarely apply a prescribed intervention across the whole apiary, but address each hive on a case-by-case basis. To intervene with emergency queens as a matter of course, as we have seen with the mainstream beekeeping practices, perpetuates disruption and illness in our beehives and has little to offer that is future-bearing. As Steiner pointed out in *Bees*, "It is still true today that wherever we intrude upon these powers of nature, we tend to make things worse rather than better," (20). Well, after "fifty to eighty years", we can certainly see that a crossroads has been reached.

The short-term benefits of artificial queen rearing have met the limitations of health and well-being. Moving forward with the same mindset and practices can only continue to weaken the bees that beekeepers, and all of us, are so desperately in need of keeping. On the other hand, as Steiner wisely remarks in the bee lectures, we must also resist becoming fanatical about this subject, which would simply bring us from one extreme to the other. A clear understanding of the necessary conditions for the development of a true queen provides enough ground for us to confidently tread a middle path and offer a helpful solution to toward healing this crisis.

References

1. Philip T. Starks. 2014. *Vasculature of the hive: heat dissipation in the honey bee (Apis mellifera) hive.* Naturwissenschaften. Tufts University.
2. *Queen substance* is secreted by two large glands that the queen has in her head and passed through the hive from worker to worker. This substance is said to unite the workers together, change their body chemistry and odor to be unified, and inhibit the worker's ovaries from becoming active, as in the case of *laying workers*.
3. Ian Stell. 2012. *Understanding Bee Anatomy*. The Catford Press
4. Amiri, E., Strand, M. K., Rueppell, O., & Tarpy, D. R. (2017). *Queen Quality and the Impact of Honey Bee Diseases on Queen Health: Potential for Interactions between Two Major Threats to Colony Health*. Insects.
5. The situation of *laying workers* is neither relevant nor important for this article, although the phenomenon is vastly interesting and is the outlying exception for how drones can come about in an abnormal situation.
6. Seitz N., Traynor K.S., Steinhauer N., Rennich K., Wilson M.E., Ellis J.D., Rose R., Tarpy D.R., Sagili R.R., Caron D.M., et al. 2015. *A national survey of managed honey bee 2014–2015 annual colony losses in the USA*. J. Apic. Res.
7. A *swarm cell* is a true queen cell, vertical and round, which is given this name because during the lead up to a swarm, anywhere from ~4-10 new queens are raised by a single colony. These are then termed, swarm cells.