The Ideal Nucleus

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Brood frame number and queen types

A queen's egg laying in a colony and her effect on colony population are important concepts, as the number of eggs a queen lays is linked to her own genetic and physical abilities. Yet the number of eggs a queen lays each day is also determined by the number of cells the worker bees prepare for her to lay into. This number is related to the colony's strength, especially its population of nurse and house bees. For the beekeeper who makes nuclei for his or her own use, or for the beekeeper who buys nuclei for new colonies, we need to evaluate the impact of the start-up bee population of a nucleus and the number of frames of brood used to establish a new colony, and how these factors impact on colony growth in adult bee population. This is important for the many beekeepers that are making increase colonies and trying to determine what strength they should make these new colonies.

A standard Langstroth deep frame has space for about 6,400 worker cells when both sides of the frame are added together. (The usable space on a frame is about 16.5 x 7.75 inches. There are roughly 25 cells per square inch, and two sides to each good frame.) It is highly unlikely that any colony will have completely filled frames, so we will use an adjustment for our discussion. At 75% adult bee emergence, we will have about 4,800 workers emerging from a frame. This allows for spotty brood, *Varroa* loss, diseased cells removed by hygienic behavior, untouched corners filled with pollen and nectar, drone brood, and physically unusable areas on the comb. Fig 1 shows a frame with about 70% sealed cells. Since nothing is precise in beekeeping, we must keep an eye on bee population and brood comb area as we evaluate colonies we assemble or purchase. I try to visualize frames in 1/10th frame increments, and estimate the brood area to the closest 10%. While my .6 and my .7 may at times overlap, I am confident that my .8 is roughly double the brood area of a .4 brood frame.

Colonies of different genetic stocks have different buildup rates. A strong Italian colony may have very full frames early in the season, while Russian and other stocks will have much smaller brood areas.

We will discuss two important factors in developing colony populations: The number of frames of brood an increase colony (split, nuc, nook, divide, etc.) receives when it is made up, and the stage of a queens' development – day-old larva, ripe queen cell, sexually ready virgin, mated queen or parent queen. A laying queen removed from the parent hive will have little delay in production of brood, while forcing a new increase colony to raise a queen from brood is the least satisfactory means of making increase because it takes seven weeks for the first new brood to emerge. This is due to the time the bees must spend to raise the queen plus the time for the queen to emerge, sexually mature, mate and lay eggs. Also, the queen's quality is suspect considering the possibility of poor rearing conditions in a small nuclei. It will be three more weeks before the new queen's eggs are transformed into emerging bees and contribute to the growth of the new colony.

While there are various software programs for modeling honey bee colonies, for this discussion I used simple Excel spreadsheets to illustrate several key points about bee populations. Let's explore this vital area of beekeeping.

Number of brood frames used in a nucleus colony

I projected the number of bees that will emerge in colonies made up with one to eight brood frames. These are the guidelines I used in developing the model in the spreadsheet:

• Each frame has an average of 75% emerging workers, or 4,800 bees/frame. Not all nuclei colonies are identical, so there will be a lot of variation based on the colonies you use to remove brood for nuclei.

• For each frame of brood moved, I estimated there is a half pound of adult nurse bees on the comb needed to warm the brood and keep it alive until sealed brood emerges. I allowed for 1,600 bees for each half pound of bees. This too is highly variable. The key is to use nurse bees, not foragers, an assumption I made in my mortality figures.

• Adult bees constantly die in a colony, so I adjusted the adult bee population as the spring season developed. Brood mortality was figured into the 75% emergence figure.

• Diseases, mite infestations, and wild weather are not part of spreadsheet, but cannot be ignored: a severe chalk brood attack may reduces adult bee emergence by 50% or more in badly infected colonies. (Fig 2). This can be pretty unnerving when checking the hive two weeks after it is assembled.

• Since this is theoretical, I decided to make all these nuclei colonies on April 15, and follow them until June 15 when nectar flows are underway for much of the northeastern quadrant of North America. Clearly these are approximations, and represent a healthy amount of wishful thinking.

As one would expect, the stronger you make a nucleus the stronger the final colony (Fig 3). The model shows why a single frame of brood and half pound of bees is not enough to develop a productive colony in two months – there just are not enough bees. After a month, the colony has just 5,800 adult bees, less than the adult bee population of a two-pound package. This is not adequate for full colony growth, but may meet some beekeeper's needs for mating queens or where the nectar flow is very late in the season – like goldenrod.

Compare that with a colony developed from eight frames of brood and about four pounds of bees. One month after being established the colony will have about 46,000 bees, and two months after set up the colony will have nearly 70,000 bees. Unless such a colony is managed for swarming, a major portion of the beekeeper's efforts may end up in a tree somewhere in a nearby woodlot. Such a large colony is rarely made up by beekeepers, but could be made just before a nectar flow to produce a great deal of honey, especially comb honey.

Note: a colony with eight frames

Figure 1. *Frame with about 70% sealed cells.*

of brood and bees is much stronger than a colony with eight frames of bees. The former counts frames of stored honey and pollen as well as brood, and reflects the size of the entire brood nest.

Figure 2. *A severe chalkbrood attack in a nuc can slow, or stop growth.*

Some beekeepers remove bees, brood, honey and pollen from a single colony to make up multiple nucleus colonies. Commercial beekeepers like Richard Adee and family (the largest beekeeping operation in the universe at present) have developed a method of dividing the resources of one full colony into four increase nuclei, dividing the brood, honey, pollen and empty frames into four units. Each new nucleus then receives a queen cell for production. Once the queen is mated, the colony is put on a truck along with thousands of other increase colonies and moved to pollination or honey production locations. Some beekeepers call these Mississippi Splits, because of the original location the Adee family used as a winter bee operation. Like all beekeepers, the Adee's methods constantly evolve – apparently well enough to grow to 100,000 colonies.

Look at the possibilities nuclei colonies create. If you have a three-brood frame nucleus, in two months it will have about 34,000 bees; a four-brood frame nucleus will have about 41,500 bees, and a five-brood frame nucleus will have about 48,200 bees. For me, a two-month old colony with a population range of 34,000 to 48,200 bees is growing well and should collect a good honey crop or provide good pollination services. If forage is present, the colony will continue to grow, while the urge to swarm should be minimal. As a bonus, there has been a break in the brood cycle, which restricts *Varroa* mite population growth.

In the northeastern corner of the country many beekeepers use a deep frame hive body divided into two five-frame nuclei, often called a double nuc. (Figs. 4-5). This provides room for two or three frames of brood, a frame of honey and one or two empty combs for the queen to lay into. Adding bees attached to the frames and maybe a shake more will give you about 3,200 or more bees, or roughly a pound. The combined heat from the two colonies growing side-by-side stimulates growth in each five-frame nuc. These bees will keep the brood warm and care for the queen before and after she is released from the queen cage or emerges from the queen cell. In about a month each colony will be so strong that it will need to be moved into regular eight- or ten-frame equipment. Left in the small quarters, the nucleus will not expand further because there is not enough room. The colony will slow development, and may swarm. Some beekeepers add supers to nucleus colonies to keep them growing and to prevent swarming.

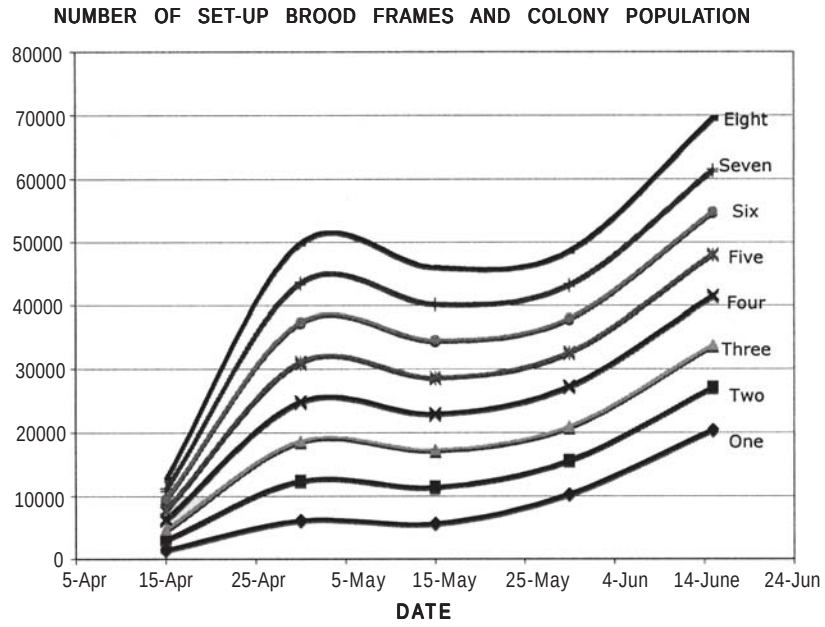

Figure 3. *A strong start (eight) makes a significant difference in the size of the colony eight weeks later.*

Impact of the queen status used in increase colonies

A laying queen is best; letting the bees raise a queen from worker brood is the worst. The latter includes queen failures when the queen dies and the bees must replace her from brood in the colony (if they have it). Let's discuss this effect, using these guidelines in a spreadsheet (Fig 6):

• Each nucleus was made with standard frames with an average of 75% emerging workers, or 4,800 bees/frame. I used three frames of brood for this model, which is on the strong side.

• For each frame of brood, I added one half pound of adult nurse bees to warm the brood and keep it alive until the sealed brood emerges. Thus, I allowed 4800 bees with three frames of brood.

• Each queen will lay an average 1,200 eggs per day after being installed and up and running full speed. Some days she will lay fewer eggs because there is no place for her to put them. Even queens have bad days and labor problems.

• When the beekeeper assembles the nucleus, it contains primarily sealed worker brood, and little open brood (eggs and larvae). This affects the colony age distri-

Figure 4. *A double nuc, with four frames on each side of a divider board.*

Figure 5. *Lids with feeder holes for each nuc.*

bution in all colonies as they develop, and is not a recommendation.

• Various queen types, based on stage of development, were used in the spreadsheet. They are:

Mother queen – Time for brood emergence is 21 days. Here the nucleus colony receives the queen from the parent hive, and there is no interruption in egg laying. As a result, you will have new bee emergence in about 21 days. In four weeks we expect to see about 27,000 bees in this three-frame nucleus; in seven weeks the population will approach 50,000 bees.

Laying queen – Time for brood emergence is 28 days. Here you must purchase or raise your own queen and introduce her into the nuc. Allow seven days for her to be released and start laying (to be conservative), add 21 days for her first adult daughter workers to emerge and join her in the hive. This is 28 days. In four weeks we expect to see about 18,500 bees in the hive, in seven weeks the population will be around 42,000 workers.

Virgin queen – Time for brood emergence is 31 days. Overproduction of queen cells often leads to a supply of caged sexually mature, ready-to-mate virgin queens. Allowing 10 days for release from an introduction cage and mating and 21 days for first brood emergence, virgin queens will provide bees in just a few more days than a mated queen. Expect 17,400 bees at 28 days from the founder bees and brood; expect 37,700 bees at seven weeks. This is just a bit less than a mated queen, which makes me wonder why sexually ready virgins are not used more often, especially since the queen is emerged and can be inspected for color, size and even behavioral screening.

Queen cell – Time for brood emergence is 37 days. Many beekeepers put a mature or "ripe" queen cell into mating nuclei. In fact, most commercial beekeepers use queen cells. Allow 16 days for a ripe queen pupa to emerge, mate and start laying, plus 21 days for the first worker bees. This is a total of 37 days for first emergence. At seven weeks expect 31,200 bees.

Queen raised from brood – Time for brood emergence is 49 days. There is a full seven-week delay when you expect a colony to raise its own queen. This may provide good *Varroa* control by providing a break in the brood rearing, but it is very costly in terms of lost buildup. I count it this way: the queen will be raised from a young larvae, so add 13 days for her to emerge from a queen cell. To this add 15 or 16 days for the queen's maturation, mating and egg laying. Then, of course, you still must wait 21 days for worker emergence. This puts the first emergence at 49 or 50 days. For seven weeks, the colony has not yet added any new bees. The population has been stuck at 17,400 bees since the last of the brood emerged. Of course, during hive inspections you have seen the formation of queen cells, bees preparing for the queen to mate and start laying, and then the new queen's brood appear. It's a fun and educational process to watch, but the 28-day lack of open brood messes up colony balance, severely reduces the stimulus to forage for pollen usually needed for royal and worker jelly production, and reduces comb construction and food reserve storage.

Colonies with queens that fail fall into this last category. While the worker bees do not age as fast when not rearing brood, they are older and will be poorer nurse bees. Either make the decision to requeen, or combine these bees with a growing unit so the bees will be of some benefit to the recipient colony

The beekeeper effect

As beekeepers work they consciously and subconsciously impact the colonies they manipulate. A beekeeper creating a single frame nuc may pick the one frame with 95% sealed brood found during inspection. Likewise, a larger nuc may be made from a number of frames containing less than 70% future worker bees. There are always frames with a combination of brood, pollen and honey. How do these compute into this discussion? The largest variable in increase production is the beekeeper's decisions.

Addition of a frame of brood before worker bees emerge. One clear advantage a beekeeper can give a nucleus colony is to add a frame of sealed brood during the buildup time before a queen's daughter workers have emerged. This corrects the age imbalance created by adding only sealed brood to the nucleus and it will serve as a boost to bee population. Removal of bees from a strong colony is one swarm management tool beekeepers have, especially if done in the late April/early May time period. Beekeepers can also add a shake of bees to the entrance of a weak hive and add the bees from a brood frame from another colony. Small swarms may be used in the same manner, if not in an area where there is a risk of catching African honey bees, however remote.

The Connecticut nucleus colony

This allows us to reach a compromise, in order to find an optimal plan for a nucleus. What is the per-

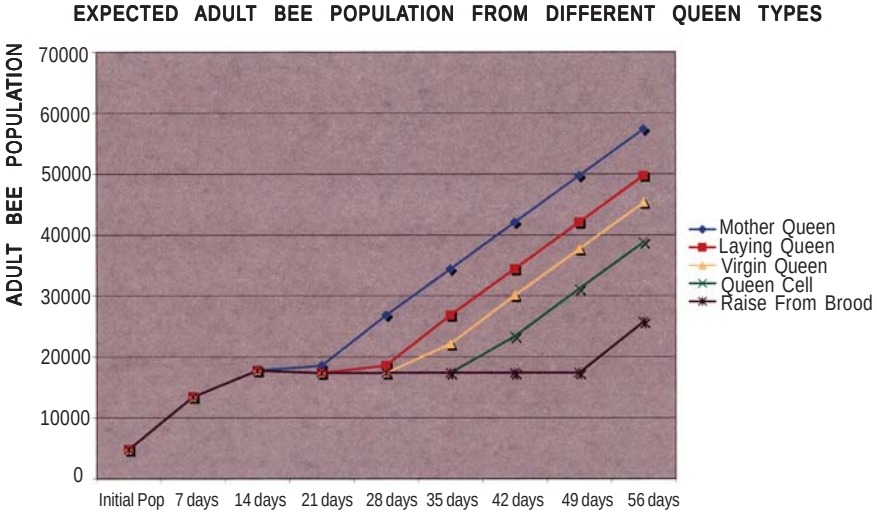

Figure 6. *Growth rates based on queen type.*

Figure 7. *Marked frames in the Connecticut double nuc.*

Figure 8. *Worker comb filled with honey.*

fect nuc? Is there a perfect nucleus colony for a large number of beekeepers? One way to find out is to look at what successful beekeepers are doing for nucleus production.

Ted and Becky Jones are Connecticut sideline beekeepers keeping bees full time in early retirement. They produce between 100 and 150 nuc colonies a year for sale and for their own colony replacement and growth. They operate a nuc making operation that many would be wise to study. They have learned from other Connecticut beekeepers, and have tried to improve their process. They do not take credit for this process, but point to those who impacted their thinking, probably going back to Langstroth, and those who influenced him.

A newest part of their program is to draw out new (and dated) combs the Summer before the nucs are made, so that they have fresh, new drawn combs to use in making increase (Fig. 7). This reduces the risk of exposure to stored pesticide residues and disease spores in old combs. Another idea so old it is new again is to have surplus worker combs filled with honey and pollen, a key to their colonies' success. These combs are integrated into over-wintered colonies. The frames are dated by year, so Ted and Becky know they are using new comb in their nucs. They set aside a deep frame of honey for every nucleus they plan to make, and store the honey for use in the Spring (Fig. 8).

They give each nuc one frame of sealed brood, and one of open brood. They have pre-assembled double nuc boxes they carried to the apiary, with two empty drawn frames, two frames of foundation, and one frame of stored honey. As they work, they take turns finding brood frames while the other assembles and moves combs around. Both check each brood frame for the queen. They add enough nurse bees to cover the brood.

They carry two frames of foundation into the apiary, holding the place of the future brood frames, and these are traded with two frames of brood. The parent colonies will draw out the foundation wax quickly if conditions are suitable. This means every colony produces at least two new brood frames each season.

They schedule April queen shipments from California and Hawaii and introduce a queen to each nuc as they make them up, putting the queen cage between the two frames of brood. They estimate the queen is caged for five to seven days before emergence. They return on the 7th day to check. If the queen is not out, they walk the queen out onto the frame. Then they leave the colony alone until two weeks have passed. They then can check the queen's egg laying and how the nuc is doing. If there is a queen failure, they deal with it at that time. They do not let the nuc just sit there.

All nuclei are moved to a new holding location, and kept fed by frames of honey. Lately they have had to surround all their colonies with bear fences, part of modern life in Southern New England. Ted estimates there are 50 or 60 bears in his hometown, a suburban bedroom community adjoining Hartford. Ten years ago bears were a novelty in the state. Not anymore.

When the CT nuc is put into a spreadsheet, some of its strengths pop out (Fig. 9). Because they use two frames of brood, one emerging and one open (primarily larvae), there is continuous addition of emerging workers for 21 days. There is a minor seven-day decline in population due to the low level mortality I built into the adult bee population. At 28 days the purchased queen's daughters are emerging, and the nuc rapidly expands. Ted Jones says the nucs have brood on four frames at that time, and are ready to move into 10-frame equipment (or cardboard delivery hive boxes for the customer) at one month. At that point the population is ready to explode with new emerging bees. Ted said some years the nucs are ready for the customers at three weeks. Those were the Springs when they found brood combs with 90% or more sealed brood. In other years, they have to wait until the brood from the new queen has emerged to make up for a shortage of brood.

The Jones didn't want to say too much about the year they had to delay nuc delivery into the Summer. That was when "their" she-bear used the nucs as a snack as she moved from one apiary to the next. She was captured (by the State of CT) and released 20 miles away. She returned in three weeks to continue her repast. She was moved from the area again. Later Ted learned the bear was killed on an interstate highway. He did not say if a beekeeper was driving the truck. BC

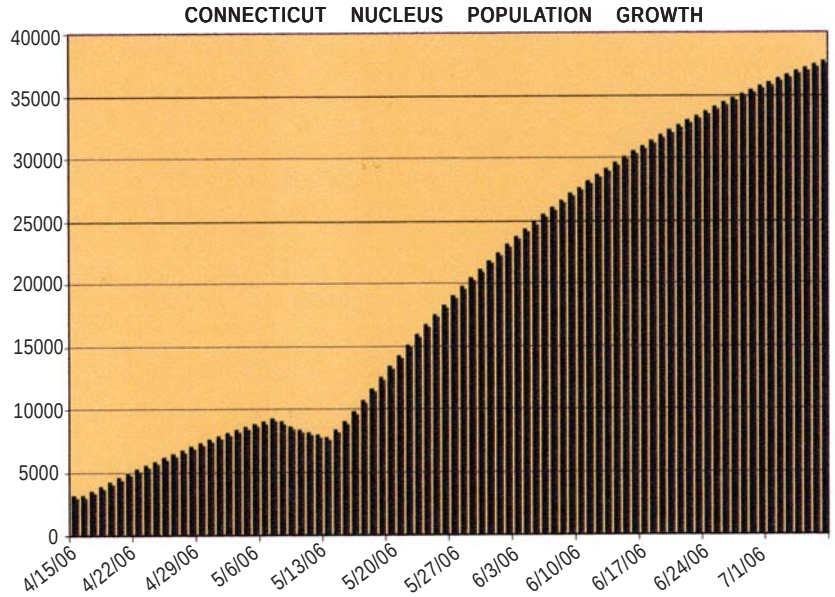

Figure 9. *Population growth curve for the Connecticut nuc.*