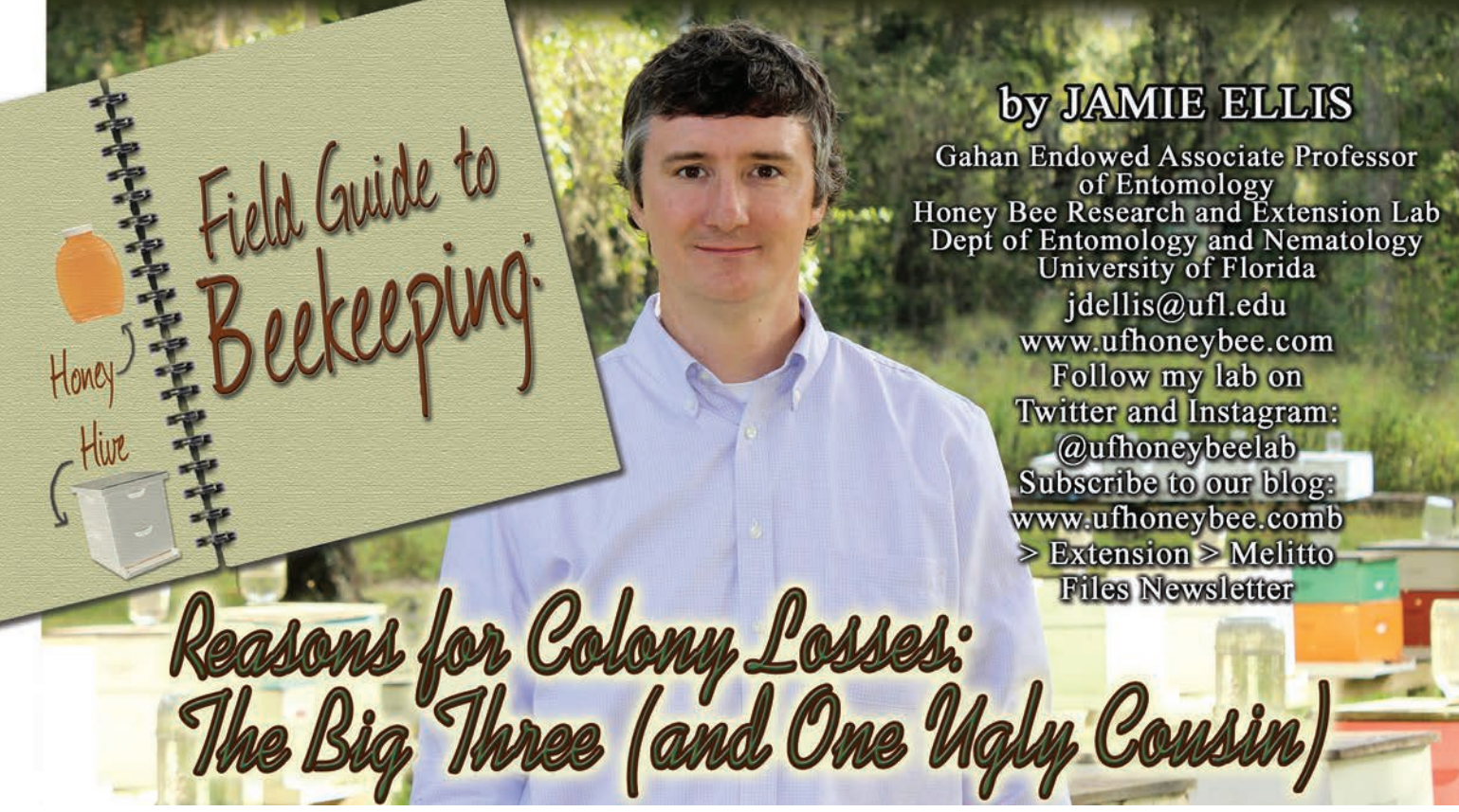

Reasons for Colony Losses: The Big Three (and One Ugly Cousin)

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There are a number of stressors that impact honey bees and their colonies. In fact, I wrote a two-article series about the stressors bees face and included 32 biotic (Ellis 2016a) and 31 other stressors (Ellis 2016b) of honey bee colonies. That means there are at least 63 stressors that can affect your bees! Coupled with this, bees have been dying at alarming rates since 2006, at a national yearly average of around 30%. Herein lies a fundamental problem for many beekeepers. Bees seem to be dying left and right and up and down. What are we to do? How can we keep bees alive at all considering the huge number of stressors they face? How can we make sense of all the noise? How do we know what matters most?

Enter the Bee Informed Partnership (**https://beeinformed.org/**), or BIP for short. I do not have time in this article to share all that BIP does for beekeepers (and they do a lot). What I do want to highlight in this article is that BIP publishes yearly colony loss reports (**https://beeinformed.org/results-categories/winter-loss/**). These loss reports tell us our average winter, summer, and yearly loss rates for managed colonies in the U.S. They break these loss rates down by state, thus allowing you to see how your loss rates compare to those of other beekeepers in your state. One of the things I most appreciate about the loss reports is that they list what the nation's beekeepers say are the key stressors that are responsible for killing most of their hives in a given year (BIP calls this "self-reported causes of losses"). In other words, BIP reports tell you what you should be worried most about as a beekeeper.

This is interesting. While there are many things that can affect your bees, most of the stressors I note in my articles (Ellis 2016a,b) will never be a problem for the average colony. Thus, it behooves the beekeeper to narrow down the long list of stressors to a much smaller, manageable list of things that they should address in their colonies. The BIP loss reports do this for you. BIP and its team of staff dedicated to helping beekeepers send out yearly questionnaires asking beekeepers how many colonies they had at a certain point in the year, how many they have now, and what the causes of their losses were. Using this information, they develop a table or figure of self-reported losses that one can use to rank, even if superficially, the causes of colony losses. Admittedly, these data are generated from surveys and surveys have their problems. However, I think these data are reliable because they seem to match the situation seen in the field.

If I understand the data correctly, one can rank a given cause of losses relative to other ones based on the number of beekeepers reporting that cause. That said, there might be some beekeeper bias in the data. For example, imagine an instance where many more hobbyist beekeepers take the survey than do commercial beekeepers. If many/most hobbyists think wax moths kill their colonies, "wax moths" will move to the top of the list just because most beekeepers voted for them. This can be a problem if the commercial beekeepers completing the survey managed many times more bees than did the hobbyists completing the survey because their causes of colony losses are underrepresented.

I have spent some time digesting the self-reported causes of colony loss data reported in the BIP surveys and have noticed that some interesting trends have emerged. For example, the top five stressors reported by beekeepers of all three levels tends to remain constant, though the order of these stressors varies from year to year. For example, *Varroa* always seem to be in the top five, but they may be five one year and second the next. On average, over the last decade, the top five self-reported causes of colony losses have been, in no particular order:

-*Varroa*,
-bad weather,
-starvation,
-weak in fall, and
-poor queens (sometimes reported as queen failure).

Oher causes of losses have moved into and out of the top five periodically. These include CCD, pesticides, *Nosema*, etc. I want to stress that *many* things weaken and kill honey bee colonies. However, the five I list above are the ones that keep rising to the top year after year, suggesting that they are a chronic problem for bee colonies.

I will omit two of the causes of colony losses from the list of five. The first I will omit is "weather." Weather, from year-to-year, shows up in the top five, but it is the one stressor about which we can do nothing. Weather can have a very broad impact. The weather that affects bees in Florida is different from that which affects bees in Germany. Weather effects on colonies range from extreme cold to extreme heat. It includes flooding, wind, tornadoes, hurricanes, drought, humidity and even more. Nevertheless, I cannot tell a beekeeper how to control weather in their colonies. It is not

manageable. Consequently, I will omit it from further discussion.

Next, I will eliminate "weak in fall" as something to discuss in this article. This condition appears in the top five almost every year. My problem with it is that "weak in fall" is not a stressor of honey bees. It is the result of other stressors (mites, starvation, weather, etc.). You cannot apply a treatment for "weak in fall" and you have to remedy it by addressing other problems. Thus, it is not a true stressor itself, leading me to omit it also from further discussion.

That leaves what I call "the big three": *Varroa*, starvation, and poor queens. Many other stressors affect bees and will affect *your* bees periodically. However, *Varroa*, starvation, and poor queens *will* affect nearly *every* colony at some point. This alone makes them something that every beekeeper must recognize and have the management skillset to address. Make no mistake, if you keep bees long enough, some, perhaps all, of your colonies battle the big three. You need to be ready.

1) Varroa – *Varroa* (Figure 1) is a mite that many feel is the number one threat to honey bee colonies globally. *Varroa* reproduces on immature bees and can transmit pathogens to these bees while the bees are developing. Increasingly, research is showing that the *Varroa* and its pathogen complex are significantly nastier than either is alone. A close look at the title of this article will show that I also intend to talk about "an ugly cousin." Well, the *Varroa* pathogen complex is that ugly cousin. The pathogens that *Varroa* transmit are underrepresented in the loss reports. The research data show, though, that the two work in tandem to take down even the healthiest of colonies. How does this work? *Varroa* carry pathogens that they transmit to young bees, pathogens such as Deformed Wing Virus (DWV – Figure 2). These pathogens can cause problems for the bees as they age, if the pathogens do not kill the bees outright while they are developing.

It is important you know that *Varroa* are ubiquitous and they will kill your bees. Beekeepers keeping bees before *Varroa* arrived in this U.S. talk about "the good old days" when they did not have to manage *Varroa* and when colonies just survived. Once *Varroa* arrived, beekeepers had to begin managing their bees heavily. Today, failing to address *Varroa* means that you will have no bees at all. That is a truth worth memorizing.

The excessive colony losses that have dominated our discussions the last decade have given rise to meetings galore, to "save the bees" groups left and right, to initiatives, congressional hearings, and to increased funding for bee research and education, all among other things. One of the groups born from the bee loss chaos was the Honey Bee Health Coalition (HBHC, **http://honeybeehealthcoalition.org/**). This group has published fantastic information on controlling *Varroa* (**http://honeybeehealthcoalition.org/varroa/**). I think the pdf entitled

Figure 1. An adult female Varroa. Photograph: University of Florida.

Tools for Varroa Management is an indispensable guide that every beekeeper should read and then read again for good measure. The HBHC developed a video series to accompany the pdf. You can find the videos here: **http://honeybeehealthcoalition.org/varroa/#videos**. This document and video series influenced the discussion of *Varroa* that follows.

Your bees will die if you do not address *Varroa* in your colonies (see the HBHC video entitled *Will Varroa kill my bees?*). Consequently, you *must* monitor for *Varroa* in your colonies. One of the great things about the HBHC *Varroa* management guide is that it includes a table (reproduced in this article as Table 1, with all credit going to the HBHC for its development) that notes the *Varroa* populations that are damaging to your colonies (the "thresholds"). In the table, the HBHC tells you what percent mite infestation (i.e. number of *Varroa* per

Figure 2. An adult bee infected with Deformed Wing Virus.

Table 1: Treatment thresholds by phase; (%=Number of mites/100 adult bees).

*This table is reproduced in its entirety from the Honey Bee Health Coalition's *Tools for Varroa Management* guide. I credit the Honey Bee Health Coalition for the information contained herein.

Colony Phase	Acceptable - Further control not needed	Caution - Control may be warranted	Danger – Control promptly
Dormant with brood	<1%	1-2%	>2%
Dormant without brood	<1%	<2-3%	>3%
Population Increase	<1%	<2-3%	>3%
Peak Population	<2%	<3-5%	>5%
Population decrease	<2%	<2-3%	>3%

Acceptable: Current mite populations are not an immediate threat.

Caution: Mite population is reaching levels that may soon cause damage; non-chemical control might be employed while chemical control may be needed within a month; continue to sample and be prepared to intervene.

Danger: Colony loss is likely unless the beekeeper controls *Varroa* immediately.

100 adult bees) demands instant control depending on what phase your colony is in at any given time. Thus, you know exactly what levels are damaging depending on your colony conditions. To summarize Table 1, having less than one mite per 100 bees is acceptable. Typically, having 2 – 3 mites per 100 bees suggests you may need to apply a control. Having three or more mites per 100 bees usually means that you must apply a control promptly or you risk losing your bees. At levels of 5 or more mites per 100 bees, your bees are dead and they have yet to realize it.

The HBHC guide tells you exactly how to determine your colony *Varroa* levels using soap washes, powdered sugar shakes, and/or alcohol washes. I will not go into the details here given that the guide does such a great job. I will only say that you absolutely should monitor your colonies. The HBHC guide recommends that you monitor them at least four times per year. My general recommendation is to do it monthly during the active season, starting when the bees are coming out of winter and continuing until the colony becomes dormant.

The final thing I want you to know about *Varroa* is that you must control their populations once you reach the appropriate threshold. I know that this point is the most sensitive of all *Varroa* topics. There are three viewpoints on this issue. There are those who will use conventional methods (usually, this means the approved miticides) to address *Varroa*. Others would not consider putting a miticide in their colonies if every bee in the nest had three *Varroa* on them. The third group of people is the group confused by the rhetoric spouted by members of the other two groups (the "I will use miticides" group and the "I will not use miticides" group). This is not an article on *Varroa* control. However, I will make a few simple statements regarding my feelings on this topic. (1) It is possible, with tremendous amounts of work, to keep thriving, productive colonies with little chemical intervention against *Varroa*. It requires diligent monitoring of colonies at all times and an all-out blitz of non-chemical *Varroa* control measures integrated to reduce *Varroa* populations (resistant stock, drone brood trapping, bottom screens, etc.). Even if it is possible to do this, it is a lot of work given that you have to monitor regularly and most of the non-chemical control approaches are labor intensive. (2) It *is* ok to use chemical miticides to address *Varroa*. I understand the anti-pesticide movement afoot in the world today. However, when used according to label, miticides do their job with minimal to no impact on bees. The problem with miticides is that rampant misuse has led to the development of miticide-resistant *Varroa*. There are only a few active ingredients that continue to work against *Varroa* today. The HBHC guide goes into significant detail about each *Varroa* control option, including their efficacies, proper use, and pros/cons of using them, etc. (3) *Varroa* cause significantly more damage to bees than the control options available to use against them (with the caveat that you follow the labels closely). It is sad to see colonies sick and dying because the beekeeper believed that not using a given treatment was healthier for the bees than killing the *Varroa* with the treatment. *Varroa* kill bees. You should kill *Varroa.*

What should you do about *Varroa*'s ugly cousin (the *Varroa*-associated pathogens)? The answer is not clear. It would be easy to say, as most do, "control the vector (*Varroa*) and you will control the pathogen." I have heard that said, and have said it myself, a thousand times. However, I do not think it is that simple. Furthermore, we have no antiviral drugs for bees. I know that some may be forthcoming, but this could take years and we do not know what their efficacies will be, if they are efficacious at all. My real reason for mentioning the ugly cousin is to reinforce the idea that you cannot separate the two. It is important to know that *Varroa* are in your colonies and they are carrying some nasty things with them.

To summarize the *Varroa* issue: (1) monitor your colonies and (2) treat your colonies when they exceed the damage thresholds. Remember, beekeepers consistently list *Varroa* as one of the "big three". Please, control your *Varroa*. When you are done, control them again. Your bees will thank you for it (because they will be alive to thank you).

2) Starvation – Of all the big three, this is the one that frustrates me the most. It shows up in reports in different ways. The BIP reports usually list it as "starvation," but I like to use the phrase "nutritional management" which, of course, includes starvation, but also includes a lack of quality food in the environment for the bees. The reason starvation frustrates me so much is because it is the easiest of the big three to address. When your bees need food, feed them. It is as simple as that…or is it? [Quick disclaimer: When I say "food" from this point forward, I mean "honey" even if honey is not bee food.]

Bees starve for two reasons. First, they have no food in the nest. Second, nothing is available in the environment that can compensate for this lack of food in the nest. Starvation can occur at any time of the year. It often occurs while the bees are coming out of winter. Perhaps they had an unusually long winter and did not store enough honey to last the entire winter. Maybe there are no major nectar flows available in an area, leaving the bees unable to collect enough to keep up with the needs of a growing colony. For most beekeepers, however, colonies starve in/around winter. Consequently, the astute beekeeper has to know going into winter if their colonies have enough stored honey to survive winter. I want to stress, starvation can happen at any time. Thus, a beekeeper should always

Figure 3. Hoisting a colony from behind to determine how much food it has. ***Photograph: University of Florida.***

be able to recognize when their colonies need food and how to feed them.

To my knowledge, there is no up-to-date U.S. guide to honey bee nutrition, including starvation and general nutrition management, like that the HBHC produced for *Varroa*. There is, however, an Australian guide to bee nutrition. Its name, rather humorously, is *Fat Bees Skinny Bees* (Somerville, 2005 — **https://rirdc.infoservices.com.au/items/05-054)**. It is a great document. In fact, I like it so much that I feel that something like this needs to be developed for U.S. beekeepers (I am looking at you Honey Bee Health Coalition. ☺)

That said, I think it contains information that can be of value to beekeepers in the U.S. and around the world.

How do you know when your bees need food? The simplest way is to hoist your colony with one hand from the bottom box (Figure 3). I usually try to do this from behind the colony. Grasp the handle on the lowermost box and try to rock it forward, off its stand, with one hand. Colonies that need honey are easy to rock forward, thus signaling that they need to be fed. Colonies that are hard to lift with one hand generally have enough honey, with no further action required.

Figure 4. A colony fed sugar syrup via a jar feeder on top of the hive. ***Photograph: University of Florida.***

What should you feed bees? There are two options for supplying sugar to a colony. First, you can feed bees sugar water or sugar patties (some beekeepers call the latter "fondant" or "sugar cakes"). Both of these rely on the use of granulated sugar that is either dissolved in water and fed as a syrup or mixed into a cake. The second option is to feed bees corn syrup. Most people just feed whichever is cheapest at the time. How should you feed bees? It is up to you (Figure 4). This is one of those "there is more than one way to skin a cat" situations. At the end of the day, it is less important how you feed your bees than it is to feed your bees if they need it.

You must monitor and feed your bees when necessary. Be prepared to do it. There is no shame in giving bees food. People like to say that feeding bees is not natural. Neither is keeping and managing bees. Given that we are managing a wild creature in a domestic setting, there are times we need to intercede to give them the best chance of survival. Please, do not let starvation end up being a reason your bees die. I look forward to the day we have a guide to honey bee nutrition. Until then, just remember: "hoist" and "feed when light".

3) Poor queens **–** Nearly every year, poor queens (sometimes called "queen failure") seem to make it into the BIP's top five reported causes of colony losses. Queens (Figure 5) can be poor or fail for a number of reasons. These include, but certainly are not limited to:

-shortened lifespan
-low or reduced egg output
-poor selection, leading to unproductive offspring who may be prone to illness
-infertility
-unsuccessful mating flight (never mated due to inclement weather, did not mate with enough drones, etc.),
-drone layer (only lays infertile eggs), and
-has a spotty pattern (Figure 6 – uneven distribution of randomly aged brood, many cells in brood nest containing no brood).

Many beekeepers say that queens are not living long enough or that they are not of sufficient quality (not producing enough, high quality offspring). To be honest, the topic of poor queens is the most difficult of the big three to discuss. It seems to be more of a moving target. After all, your definition of a poor queen may vary from my definition. There are no good queen management guides available today and one seems sorely needed (another job for the HBHC or other industrious group. ☺)

Despite the difficulties associated with addressing this topic, there are some general comments about poor queens that I can make. First, the demand for bees has never been greater. Those selling packages, nucs, and queens are having a hard time keeping up with the demand for these items. Thus,

there can be little motivation to invest in the time and labor it takes to produce quality queens when the demand to produce many queens is so high (a focus on quantity often comes at the expense of a focus on quality).

Second, the science of breeding bees is straightforward intellectually, but the practice of breeding queens is expensive, time consuming and laborious. It is possible to breed beneficial traits into bees. However, it is a lot of work to do. Furthermore, the mating habits of queens and drones makes it difficult to maintain a stock, given that queens leave their hives and mate with multiple drones that are not under your selection. I think about it this way. You may have the world's most perfect daughter, perfect in every way. However, you have a hard time controlling who she brings home – do you not? Queens are the same way. You can invest a lot of time in their selection, but it is difficult to control the source of drones with which they mate. Of course, you could own an island, or be an expert in instrumental insemination. Yet, the former is not an option for most of us and the latter requires special instrumentation and skills.

Third, no one knows quite what to look for when a queen is "poor". I provided at the beginning of my discussion of this topic a list of qualities that many believe poor queens have. However, I have managed very productive colonies headed by queens exhibiting one or more of these qualities. Knowing your bees are starving or that they are succumbing to *Varroa* is easier than knowing your colony has a failing queen. For example, you generally find out that the queen was producing unproductive offspring *after* the production season has passed. By then, it is too late!

What can one do to remedy the poor queen issue and reduce the number of colonies lost to poor queens? I list some recommendations below.

A – Requeen your colonies yearly. Young queens often are more productive (lay more eggs) than are older ones. You possibly can forgo this recommendation if your old queen remains a prolific egg producer and if is her offspring are productive.

B – Requeen your colony if you notice any problem with your queen. Many new beekeepers are so happy that their colony has a queen at all that they are willing to put up with an inferior queen for the comfort of knowing they have one. However, this is not a good way to manage bees. Replace unproductive queens or queens suspected of being poor in any way.

C – Requeen your colony if it exhibits any undesirable traits. For example, requeen defensive colonies. Replace queens from chalkbrood-infested colonies, or, for that matter, colonies that have recurring issues with other pathogens. This, after all, is a sign that the queen's stock is susceptible to these issues.

D – Purchase and use queens from reputable breeders. Ask other beekeepers who they would recommend or try a few queens from different sources and decide for yourself.

Figure 5. A queen surrounded by her retinue of workers. *Photograph: Mike Bentley.*

E – Purchase and use queens selected for *Varroa* tolerance or resistance traits. I wrote an article about the queen stocks available in the U.S. (Ellis, 2015). Decide on which of those you would like to try and contact the producer of that stock for advice on which breeders to use as your source of queens. For example, I would contact the USDA Bee Lab in Baton Rouge if I wanted to find a queen breeder who produces VSH (*Varroa* Sensitive Hygiene) queens.

F – Contrary to what you hear, do not rear your own queens if you have five or fewer colonies or if the density of feral bee colonies (those living in the wild) is low. Many people, me included, believe that inbreeding is one of the main reasons queens produce spotty brood patterns. The chances of producing inbred queens has an inverse relationship to the number of colonies you have (i.e. the chance goes up as the number of colonies you have goes down).

G – Take classes, attend workshops, and read books related to rearing queens if you plan to produce your own. You can start by reading this good overview: Büchler et al. 2013 (***http://www.tandfonline.com/doi/abs/10.3896/IBRA.1.52.1.07***). It pays to invest time and energy into being educated on this topic given that queen quality is a significant contributor to colony losses.

Generally speaking, you need to learn to spot queen problems and work quickly to remedy them.

Conclusion

Will all of your colonies survive if you control *Varroa*, ensure your bees have enough food, and your queens are always good? Of course not. Plenty of other things

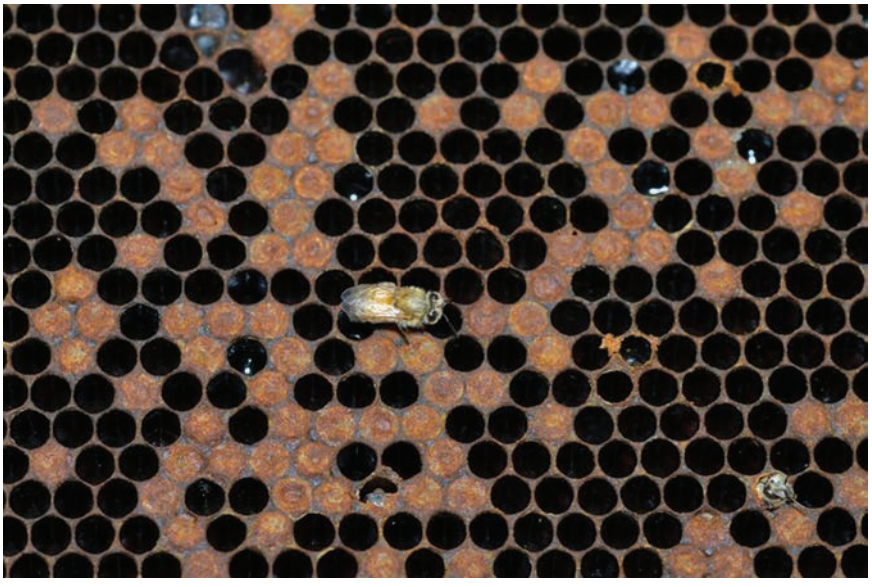

Figure 6. A spotty brood pattern. *Photograph: University of Florida.*

kill bees. However, *Varroa* (and their ugly cousins), the threat of starvation, and poor queens will plague your colonies nearly every year. It is essential that you know the threat posed by each, recognize when a colony is suffering from one of the three, and know how to help colonies when they are under attack by one of the big three. Proper management of *Varroa*, starvation, and poor queens will reduce your colony loss rates significantly.

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